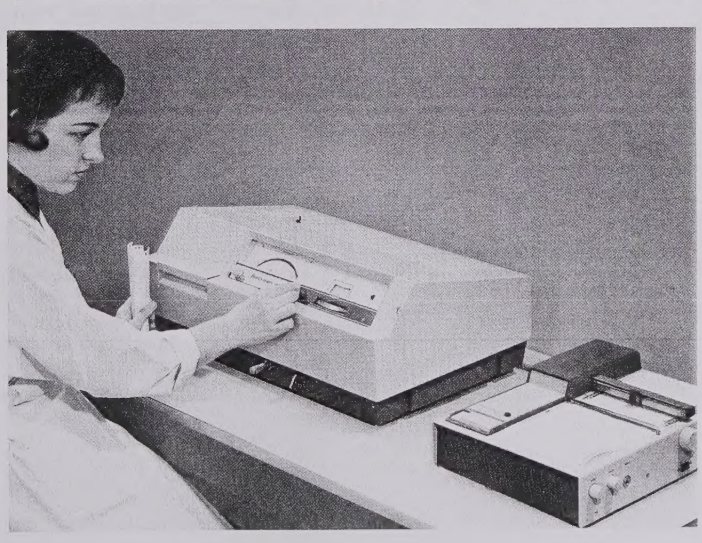
MODEL DB
PRISM
SPECTROPHOTOMETER
and
MODEL DB-G
GRATING
SPECTROPHOTOMETER



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SPECIFICATIONS

CATALOG NUMBERS

1400 Model DB Prism Spectrophotometer, 115 volts, 50/60 Hz.

1401 Model DB Prism Spectrophotometer, 115 volts, 60 Hz, with dual-speed wavelength drive (scan rates 10 and 40 mμ/min).

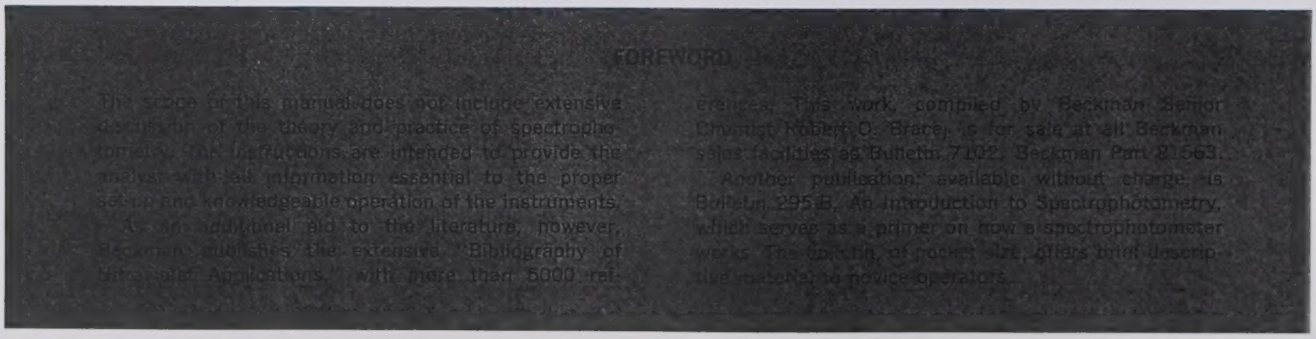
1402 Same as 1401, except 50 Hz.

1403 Model DB-G Grating Spectrophotometer, 115 volts, 60 Hz, with dual-speed wavelength drive (scan rates 10 and 50 mμ/min).

1404 Same as 1403, except 50 Hz.

	MODEL DB	MODEL DB-G
OPTICAL PRINCIPLE	Double-beam (vibrating mirror)	Double-beam (vibrating mirror)
LIGHT SOURCE	Tungsten lamp (1400 Model DB) Tungsten and hydrogen lamps (all other models)	Tungsten and hydrogen lamps
WAVELENGTH RANGE	205-770 mμ with 1P28A photomultiplier (200-800 mμ range available)	190-700 mμ with 1P28A photomultiplier (190-800 mμ range available)
WAVELENGTH PRESENTATION	Dial linearly calibrated 200-800 mμ. Readout in absorbance, % transmission	Dial linearly calibrated 185-1000 mμ. Readout in absorbance, % transmission
WAVELENGTH ACCURACY	220-334 mμ: better than 0.7 mμ 335-574 mμ: better than 1.5 mμ 575-700 mμ: better than 4.0 mμ	Better than 0.5 mμ throughout
WAVELENGTH REPEATABILITY	220-334 mμ: better than 0.35 mμ 335-574 mμ: better than 1.0 mμ 575-700 mμ: better than 2.0 mμ	Better than 0.25 mμ throughout
MONOCHROMATOR	Single, fused silica prism	Single, filter-grating; 1200 line/mm grating blazed at 250 mμ, used in first order; automatic filter selection

	MODEL DB	MODEL DB-G
RESOLUTION	UV—Better than 0.5 mμ Visible—Better than 1.5 mμ	Better than 0.2 mμ throughout
PHOTOMETRIC LINEARITY	Better than ±1.0% or ±0.01A at 0.4A	Better than ±1.0% or ±0.01A at 0.4A
PHOTOMETRIC PRESENTATION	Meter readout nonlinear in absorbance, linear in % transmission	Meter readout nonlinear in absorbance, linear in % transmission
100% LINE STABILITY	Less than ±2% from 200-700 mμ	Less than ±2% from 200-700 mμ
STRAY LIGHT	Less than 0.1% at 220 mμ	Less than 0.1% at 220 mμ
SLITS	Programmed for double-beam operation; manually adjustable from 0.01 to 2.0 mm.	Programmed for double-beam operation; manually adjustable from 0.01 to 2.0 mm.
DETECTOR	1P28A Photomultiplier Tube (R136 Photomultiplier Accessory)	1P28A Photomultiplier Tube (R136 Photomultiplier Accessory)
ABSORPTION CELLS	1 mm, 5 mm, 10 mm, 40 mm, rectangular	1 mm, 5 mm, 10 mm, 40 mm, rectangular
NET WEIGHT	65 pounds	65 pounds
DIMENSIONS	23 in. long, 14 in. deep, 9 in. high	23 in. long, 14 in. deep, 9 in. high



The scope of this manual does not include extensive discussion of the theory and practice of spectrophotometry. The instructions are intended to provide the analyst with all information essential to the proper set-up and knowledgeable operation of the instruments. As an additional aid to the literature, however, Beckman publishes the extensive "Bibliography of Spectrophotometric Applications," with more than 5000 references. This work, compiled by Beckman Senior Chemist Robert O. Brace, is for sale at all Beckman sales facilities as Bulletin 7102, Beckman Part 2563.

Another publication, available without charge, is Bulletin 295-B, An Introduction to Spectrophotometry, which serves as a primer on how a spectrophotometer works. The bulletin, of pocket size, offers brief descriptive material to novice operators.

This instruction manual gives detailed descriptions and technical directions for two Beckman spectrophotometers which are earning widespread critical recognition for their accuracy, range of versatility and ease of operation.

Covered here are the Model DB Prism Spectrophotometer and the Model DB-G Grating Spectrophotometer, illustrated in Figures 1 and 2, respectively.

Except for the dispersive element, where the prism monochromator of the Model DB is replaced by the filter-grating monochromator of the Model DB-G, the two instruments are identical.

Both are single beam-double beam, ratio indicating or recording instruments which make rapid transmittance and absorbance measurements in the near ultraviolet-visible region. Qualitative and quantitative analysis and reaction rate studies are obtainable with high resolution. Specialized techniques, such as programmed scanning, reflectance studies, or atomic absorption measurement, are made possible by addition of various easily-mounted accessories described in Section Eight.

Both spectrophotometers are housed in compact cases with console controls and direct-reading meters. Major components of each instrument are a source, monochromator, beam-switching device, detector, and amplifying and regulating circuitry.

The following instruction sections are applicable to each model, except where special points of difference or function are noted. Major differences are given in separate sub-paragraphs, headed Model DB or Model DB-G.

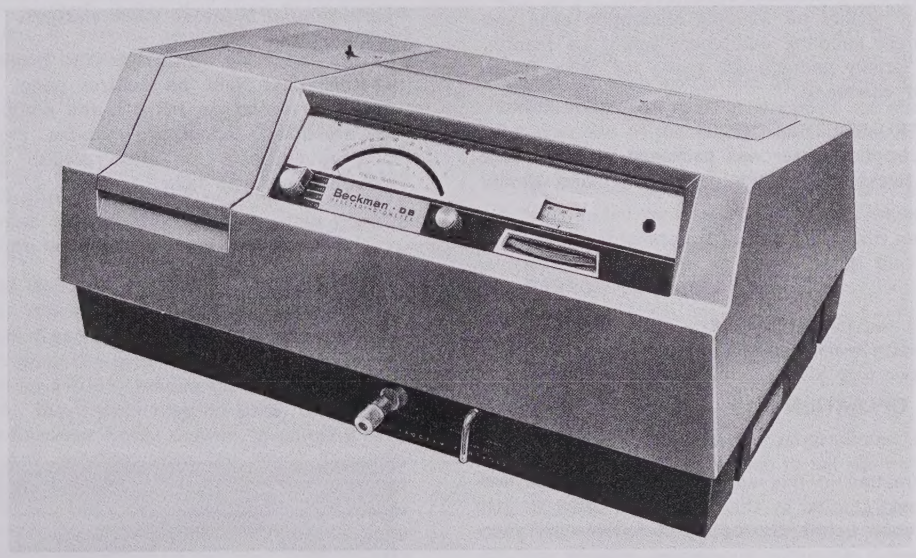


Figure 1. Model DB Prism Spectrophotometer

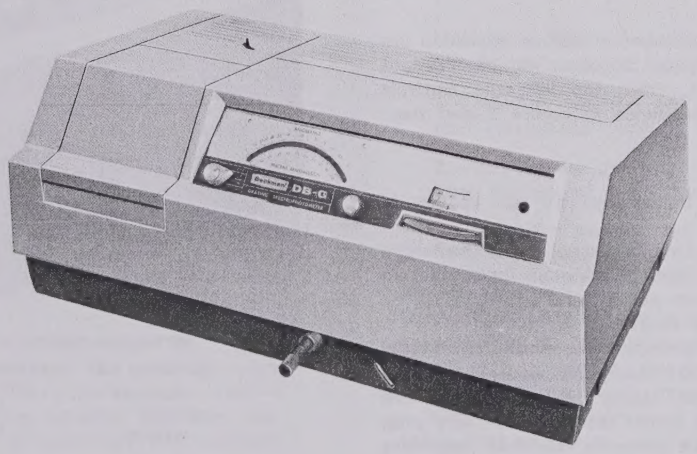


Figure 2. Model DB-G Grating Spectrophotometer

TWO INSTALLATION

Determination of location and facilities for use of the spectrophotometer are described in this section.

2.1 LOCATION

The instrument should be placed in a semi-protected area, that is reasonably free of dust and excessive moisture, and least subject to temperature variation.

Instrument performance may be affected by heavy electromagnetic fields, as would exist in proximity to large electric motors or diathermy machines. Disturbances of this nature should be avoided when determining location.

A desk, bench or counter with a stable base should be used for placement of the approximately 65-pound spectrophotometer. The chosen location should be conveniently near an electrical outlet furnishing power requisite to the instrument specification.

A nearby facility for washing absorption cells and other sample handling equipment would be helpful, as would supply and storage space for cells, accessories and chemicals.

2.2 INSTRUMENT SET-UP

Your spectrophotometer was packaged with the care given all Beckman precision instruments and should be unpacked with equal consideration. The shipping list in the container lists all items making up the complete package; compare the list with the items received to make certain none is missing.

Remove the protective shipping tape from the wavelength dial, cams, Manual Slit Adjust, sample compartment and Source Selector.

Place the instrument in its operating location and connect the power line to the power source. The power line is a three-conductor cable with a three-pronged plug that affords an earth grounding. When the electrical outlet used does not have a third (ground) contact point, use the special adapter plug provided in the shipping kit and connect its ground lead to a water pipe or other good earth ground. The earth ground bypasses static charges.

Turn the Power Switch to ON position and note whether pilot light on control panel glows. When power is turned on initially, the electronic circuitry will stabilize in about two minutes. Proper temperature equilibration for most precise operation will require about one hour.

THREE OPERATION

The information in this and the following three sections is best studied by the operator in order to gain familiarization before attempting to operate the spectrophotometer. Controls, component features and operation techniques are described. Differences, where they exist, are pointed out for each instrument.

3.1 CONTROLS

Operating controls most used in normal operation are grouped on the front panel, together with the readout meter and pilot light. From top left, the controls shown in clockwise sequence in Figure 3 and their functions are:

Power Switch

OFF — instrument is inoperative; no line voltage in circuits.

IDLE — power in all circuits except beam switching mechanism. Position used to maintain instrument in standby condition when not in use.

ON — instrument fully operative.

SCAN — energizes wavelength drive motors. (In Model DB-G, and 1401 or 1402 Model DB, wavelength drive is provided; in the 1400 Model DB, wavelength drive is an accessory.) Also shorts recorder accessory plug to remotely start chart drive on Beckman recorders when recorder and spectrophotometer are connected with recorder cable.

Figure 3. Front Panel Controls

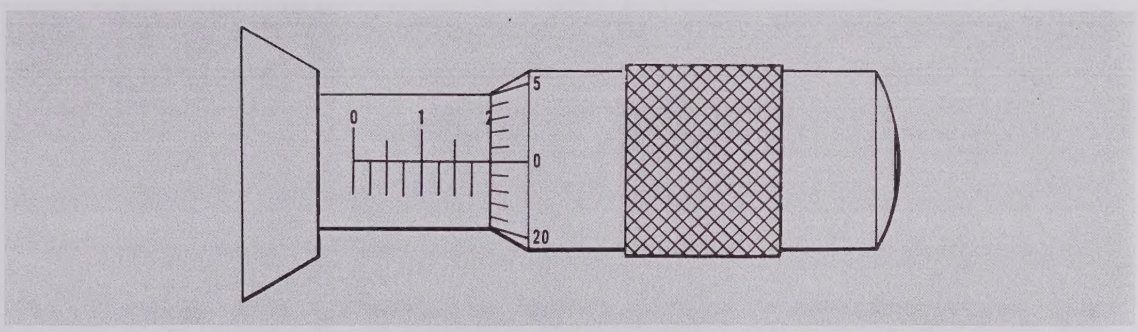


Figure 4. Manual Slit Adjust

Zero Adjust Control
Thumbwheel beneath meter dial used to set meter needle at zero. In making adjustment, opaque block should be placed in sample beam.

Wavelength Control
Rotation of this control moves the wavelength cam and sets the angular position of the prism or grating. This determines the central wavelength of the band of light passing through the exit slit. The central wavelength is shown on the dial by the hairline mark in the wavelength window.

100% Adjust Control
This control, which is marked REF on the panel, functions, when sample and reference energy levels are equal, to bring the amplifier output current to the level required for a 100% reading on the output meter.

Additionally, the control may be used, in conjunction with the Recorder Adjust Control, to adjust a fixed span (100 mv) recorder with the Scale Expander to 100%. (The Beckman Ten-Inch Recorder does not require the Scale Expander.) When doing so, meter readings should be ignored (or regarded only as a reference); presentation will be incorrect to the extent of the mismatch in 100% points on the meter and recorder.

SLIT PROGRAM CONTROLS are grouped at the bottom of the front panel:

Manual Slit Adjust
This vernier-graduated control, shown in close-up profile in Figure 4, is used to open the slit when the thimble is turned counterclockwise. Each complete turn opens the slit 0.25 mm. Eight turns from the zero slit position opens the slit to its maximum width of 2 mm. The turns are read on the sleeve scale, which is calibrated in 0.25 mm divisions. Radial graduations on the thimble are calibrated to indicate 0.01 mm in slit width; 25 of the graduations mark one complete turn.

NOTE

Always turn this control to the zero stop — but never jam it hard or overtighten at the stop — when the Slit Program Selector, described subsequently, is in a programmed (not manual) position. Otherwise, the Manual Slit Adjust may override the action of the slit cams.

Slit Program Selector (Model DB)
This is a spring-loaded manual control which permits selection of the slit program that best fits the analysis to be made. The three settings on the selector, labeled for each instrument as in Figure 3, fit the following conditions when it is pulled out and locked in the direction of the labeled positions:

MEDIUM — Designates medium slit program. Is intended for use with reference materials of lower transmittance (below 50% with respect to air). Energy level is about twice that of the NARROW program.

NARROW SLIT — Designates narrow slit program. Is best used with reference materials of high transmittance (about 50% and higher with respect to air).

MANUAL — Slits are not programmed and the Manual Slit Adjust is used to set slit width.

Slit Program Selector (Model DB-G)
Similar in all respects to Slit Program Selector of DB, as previously explained, except positions are labeled as in Figure 3, setting the following conditions:

MANUAL — Slits are not programmed. Manual Slit Adjust is used to set slit width.

1 — Position for use with 1P28A photomultiplier (standard).

2 — Position for use with R136 photomultiplier, when instrument is equipped with this detector.

One control is located atop the spectrophotometer:

Source Selector
Determines energy source. When Source Selector lever is rotated to the VISIBLE position (320 to 800 mμ), source mirror reflects radiant energy from tungsten lamp to entrance mirror of monochromator.

When Source Selector lever is rotated to the UV position (200 to 350 mμ), source mirror reflects energy from hydrogen discharge (or deuterium) lamp (if instrument is so equipped) to entrance mirror.

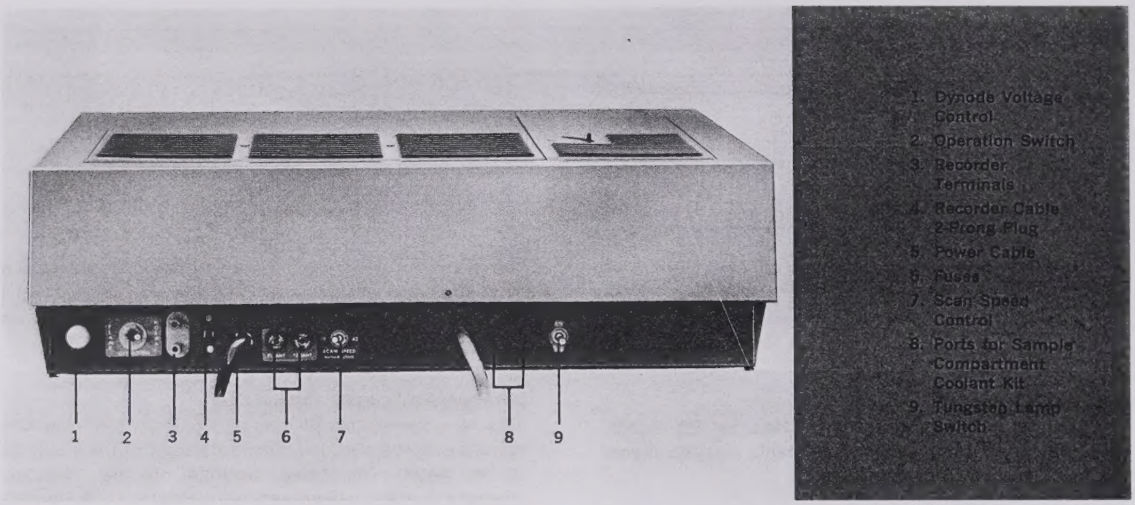

1. Dynode Voltage Control
2. Operation Switch
3. Recorder Terminals
4. Recorder Cable 2-Prong Plug
5. Power Cable
6. Fuses
7. Scan Speed Control
8. Ports for Sample Compartment Coolant Kit
9. Tungsten Lamp Switch
1 2 3 4 5 6 7 8 9

Figure 5. Rear Panel of Model DB

Controls and various connecting and adjustment features on the rear panel include the following, as shown in Figure 5 (for the Model DB) and Figure 6 (for the Model DB-G):

Dynode Voltage Control
This control adjusts voltage to the dynodes of the photomultiplier tube, thus determining gain of the system in single-beam operation. Control cannot be used in double-beam operation, since dynode voltage then is controlled automatically.

Operation Switch
Two-position switch used to select single or double-beam operation.
NORMAL — this position is for double-beam operation.
SINGLE (FLAME) — this position is for single-beam operation.

Recorder Terminals
Recorder input cable connectors. Top terminal is positive; bottom is negative or ground.

Recorder Cable Accessory Plug
Provides remote control of recorder chart drive when used with Beckman Laboratory (Five or Ten-inch) Potentiometric Recorders.

Coolant Ports
Used for attachment of coolant lines when accessory tubing is attached for use in temperature control of sample compartment.

Tungsten Lamp Switch
Turns the tungsten lamp on and off.

Scan Speed Control
Provides choice of two wavelength scanning speeds: on 1401 or 1402 Model DB (but not 1400 Model DB) — 10 or 40 mμ/min; on Model DB-G — 10 or 50 mμ/min; other speeds available with accessory wavelength speed drives.

3.2 INTERNAL ADJUSTMENTS

Potentiometers in the circuits of these instruments have adjustment features, but adjustment should seldom be required. The components with adjustment capabilities shown in Figure 7 are:

R49 Chopper Amplitude Control — adjusts amplitude of vibrating mirror system.

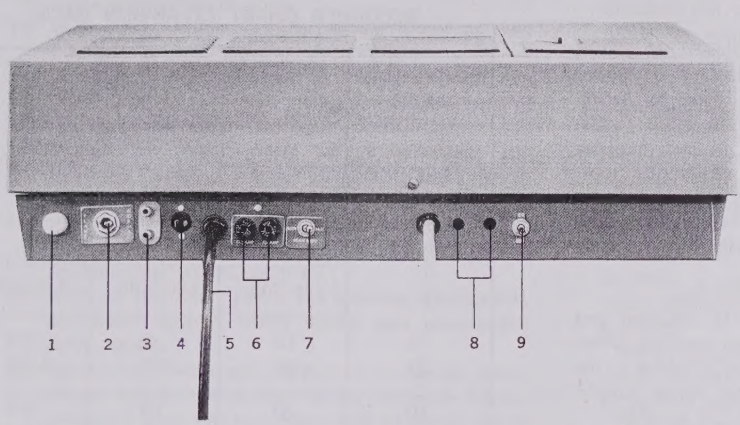
R64 Demodulator Phasing Control — adjusts switching position of Clare relay.

R17 Dynode Feedback Control — adjusts feedback within dynode high voltage supply.

R73 Recorder Span Adjust — Permits output adjustment to match a fixed 100-mv recorder. Control is variable continuously from less than 95-mv to more than 105-mv, but is factory-adjusted for a 100-mv output. Turning the Recorder Span Control fully counterclockwise opens a switch which removes the potentiometer from the circuit. This permits using the Scale Expander without physically removing the load resistors. Do not turn this potentiometer fully counterclockwise with signal applied and no external resistor such as the Scale Expander attached. This will cause the meter to deflect hard against the stops and may damage it.

NOTE

To prevent meter damage if the switch on the Recorder Span Control is opened inadvertently, the instrument is shipped with a jumper which makes the switch inoperative. However, the jumper does not interfere with operation of the potentiometer. This jumper, shown in a separate sketch in Figure 7, must be removed if the Scale Expander accessory is used with the instrument.



1. Dynode Voltage Control
2. Operation Switch
3. Recorder Terminals
4. Recorder Cable 2-Prong Plug
5. Power Cable
6. Fuses
7. Scan Speed Control
8. Ports for Sample Compartment Coolant Kit
9. Tungsten Lamp Switch

Figure 6. Rear Panel of Model DB-G

When the jumper is removed (by clipping it), be certain that the Scale Expander is connected first, or that the instrument is turned off.

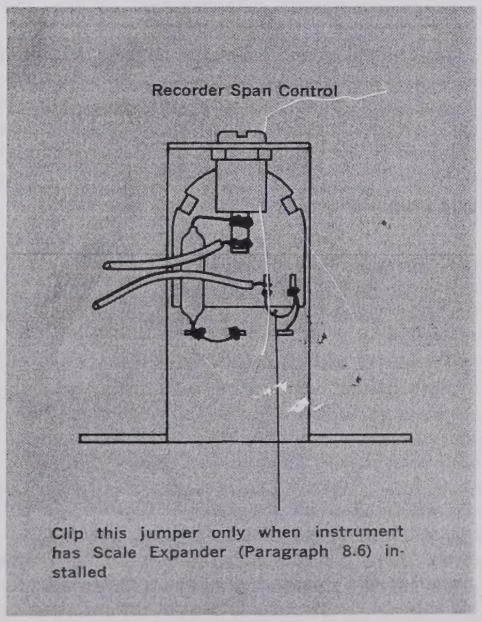
Two resistors are supplied with the spectrophotometers for modification when either a 50-mv or a 10-mv recorder is to be used. The modification includes connection of the appropriate resistor across the recorder terminals. Use the 500-ohm resistor for a 50-mv recorder; the 56-ohm resistor for a 10-mv recorder.

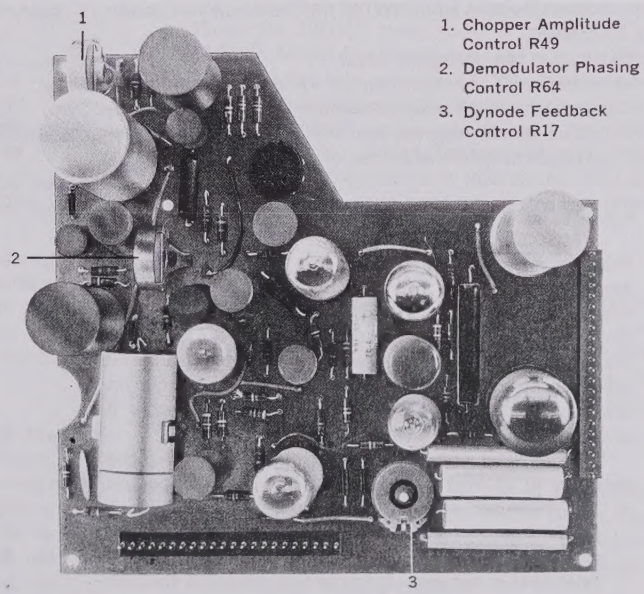
3.3 OPERATION

Both the Model DB and DB-G are designed for direct meter readout, or for operation with a recorder.

The meter provides readout of percent transmission or absorbance of the sample compared to the reference. When a potentiometric recorder is installed and connected, the instrument becomes a transmittance recording spectrophotometer. (The 1400 Model DB requires a wavelength drive motor for this use.)

Several modes of operation are possible with these spectrophotometers, but most quantitative analyses





1. Chopper Amplitude Control R49
2. Demodulator Phasing Control R64
3. Dynode Feedback Control R17

Figure 7. Internal Adjustments

are performed in manual, double-beam procedure. The various procedures are given in subsequent paragraphs. Unless noted, operation is the same for both the Model DB and DB-G.

3.4 MANUAL OPERATION IN DOUBLE-BEAM MODE

Initial operation requires turning the instrument Power Switch to ON position in sufficient time to permit proper warmup for temperature equilibration. Satisfactory operation may be obtained in two minutes but maximum stability is reached in about one hour. After the instrument is warmed up, proceed as follows:

1. Place opaque block in sample beam. With Zero Adjust Control, bring meter needle to zero scale line on meter.
2. For operation in UV range (200-350 mμ):
   a. Make certain hydrogen lamp is installed and lamp power supply is in proper working order.
   b. Turn on the hydrogen lamp, as directed in the instructions provided with the power supply.
   c. Be sure Source Selector is in UV position.
3. For operation in VISIBLE range (320-800 mμ):
   a. Move Source Selector to VISIBLE position.
   b. Place Tungsten Lamp Switch in ON position.
4. Select desired slit program, as instructed in Paragraph 7.8.
5. Rotate wavelength dial to desired wavelength.
6. Consult Section Four, and, following instructions, fill sample and reference cells with appropriate solvent.
7. Seat cells in proper positions in cell compartment. Close compartment cover.
8. With 100% Adjust Control, adjust meter to read 100%T.
9. Discard solvent in sample cell. Refill cell with sample, and replace it in sample cell compartment, seating the cell in same orientation as in previous step when 100% transmission was established.
10. Close compartment cover.
11. Read %T or absorbance value on appropriate scale of meter. Some sample with sharp absorbance bands may require fine adjustment of wavelength to find the center of the bands.

3.5 PERCENT-T RECORDING IN DOUBLE-BEAM MODE

This operation includes both the spectrophotometer and a recorder. The two instruments should be properly interconnected, particularly with respect to connections at the recorder terminals of the spectrophotometer. The remote chart speed cable from the recorder attaches to the 2-prong male receptacle on the rear panel of the spectrophotometers, Figures 5 and 6.

The following notes will help explain the role of the recorder in making an accurate chart run of spectra:

A. The recorder speed selected must be one which offers the best chart presentation at the selected scanning speed. Interpretation is easier if the relationship between the scanning progress through the spectrum and the paper advance is such that each vertical line on the chart denotes a readily-determined wavelength. The following table will help speed selection.

RECORDER CHART EXPANSION DATA

WAVELENGTH DRIVE MOTOR SCANNING SPEED (mμ/min)	CHART EXPANSION (mμ/min)		
	RECORDER CHART SPEEDS		
	½ in/min	1 in/min	2 in/min
5	10	5	2.5
25	50	25	12.5
10	20	10	5.0
40	80	40	20.0
50	100	50	25.0
20	40	20	10.0
80	160	80	40.0
100	200	100	50.0

B. The scanning/recorder chart speed relationship desired is illustrated by this example:
   A 20-millimicron/minute wavelength drive assembly and a recorder chart drive speed of 2-inch/minute delivers a chart presentation in which each one-inch abscissa interval represents ten millimicrons. Such a presentation makes wavelength determination at any point on the chart a simple matter.

To begin initial operation of the paired instruments in this mode, the spectrophotometer should be turned on in sufficient time to permit proper warmup for temperature equilibration. Satisfactory operation may be obtained in two minutes, but maximum stability is reached in about one hour. After the warmup period, proceed as follows:

1. For operation in UV range (200-350 mμ):
   a. Make certain hydrogen lamp is installed and lamp power supply is in proper working condition.
   b. Turn on the hydrogen lamp, as directed in the instructions provided with the power supply.
   c. Be sure Source Selector is in UV position.
2. For operation in visible range (320-800 mμ):
   a. Move Source Selector to VISIBLE position.
   b. Place Tungsten Lamp switch in ON position.
3. Select desired slit program.
4. Rotate wavelength dial to desired wavelength.
5. Place opaque block in sample beam and adjust meter needle to zero scale line on meter with zero adjust wheel. With Zero Control on recorder, adjust recorder zero.

7. Fill sample and reference cells with solvent, as per directions in Section Four.
8. Seat cell in sample compartment.
9. Close compartment cover.
10. With 100% Adjust Control, adjust meter to read 100%T.
11. Similarly, adjust recorder to 100% with its own Span Control, or when using fixed span recorders, with the Recorder Span Control inside the Model DB. (After initial adjustments with the Recorder Span Control, Paragraph 3.2, minor adjustment of recorder 100% can be made with the 100% Adjust Control on the front panel. This will result in minor differences between meter and recorder 100% points.)
12. Note on the chart paper the starting wavelength, slit width setting, chart speed and wavelength drive speed.
13. Rotate the Wavelength Control to the longer wavelength end of the section to be scanned. Always approach from the high side (side of longer wavelength). Motion of the wavelength dial should be slow and even.

NOTE

When using a Beckman Laboratory (Five or Ten-Inch) Potentiometric Recorder, turn Power Control Switch to SCAN position. Chart drive will begin when scanning operation starts. With recorders other than Beckman recorders, begin scan a few millimicrons above desired starting wavelength. When wavelength dial reaches desired starting point, turn on recorder chart drive.

14. To calibrate for differences in cells, run a 100%T line over the area to be scanned. This line establishes a reference for corrections on the recorded %T curve.
15. Remove sample cell, rinse, and fill with sample solution. Use the same cell and reinsert it in the sample compartment in the same orientation in which it was used in Step 8. Close compartment cover.
16. Return the chart to the starting point, so that the pen position coincides with the beginning of the 100% line run.
17. Repeat the scan. Recorder now should indicate the transmittance of the sample as a percentage of the reference transmission (100%T) over the range of wavelengths being scanned. Scan will be continuous from long to short wavelengths.

3.6 REACTION RATE STUDIES

Reaction rate studies may be conducted when the Models DB and DB-G are operated in recording mode. This is accomplished by setting the spectrophotometer at a wavelength appropriate to the study, inserting sample, and turning on the recorder. Presentation is in units of transmission, or absorbance versus time. All the steps given in Paragraph 3.5 may be followed, except that the Power Control Switch should be turned to the ON position rather than to SCAN.

3.7 DIFFERENTIAL ANALYSIS

Differences between similar (but not identical) samples may be determined when these spectrophotometers are used in double-beam operation, since the meter, or recorder, displays the ratio of sample and reference transmittances.

Since the spectrophotometer indicates 100% whenever transmittance of sample and reference are identical, readout will be 100% (at the 100% level on the recorder chart), except at the points of difference between sample and reference. The differences per se are immediately apparent as deviations from the 100% line.

In this way, by using a known material, the extent to which a slightly dissimilar material departs from these characteristics can be measured with ease and accuracy.

When attempting differential analysis, the operator should be aware of the following factors.

a. Solvent should not exhibit strong absorption within the area of the run.
b. Cells of matched pathlength should be used in order to confine all differences in sample and reference paths to the differences between the sample and reference materials.

NOTE

Because of its potential effect on results, cell mismatch, if any, should be carefully determined before conducting analyses.

c. The reference may absorb more energy than the sample, thus sending the needle or recorder pen above the 100%T point. Unless it can be determined beforehand that the stronger absorber will be in the sample path, the 100% Adjust Control should be turned counterclockwise to bring the 100%T line down to the 80%T level. If readout still is above the 100%T point, further adjustment of the 100% Adjust Control is necessary to contract the scale, or the cells may have to be interchanged.
d. For highly absorbing sample, it may be preferable to make separate runs for sample and reference solutions. This is advised because of difficulties which may be encountered in interpreting the obtained data under conditions of severe reference energy attenuation.

3.8 REPETITIVE SCAN

If it is necessary to study a time reaction of a sample over a specific band of wavelengths, follow the procedure given in Paragraph 3.5. Allow the spectrophotometer to repeat the scan as many times as required. The operator may then observe the scan in the wavelength region of interest.

3.9 SINGLE-BEAM OPERATION

When the Operation Switch, S1, is placed to FLAME on the Model DB (SINGLE-BEAM on Model DB-G), the spectrophotometer operates in a single-beam mode. Photomultiplier dynode voltage is adjusted manually by R7, the Dynode Voltage Control.

The single-beam mode is useful for checking wavelength accuracy while using a mercury, neon or other

source lamp with discrete spectral lines.

Single-beam operation also is useful in recording the energy of a source with respect to wavelength. For this application, the energy also is a function of the detector. The resultant energy curve is a combined curve of source and detector. Relative values can be obtained by recording various sources while using the same detector or vice versa. Use manual slits for energy recording.

To operate in single-beam mode, proceed as follows:

1. Place Operation Switch to FLAME.
2. Select desired slit width, or use programmed slit.
3. Manually scan through wavelength of interest, and adjust Dynode Voltage Control for on-scale reading. Dynode voltage increases as control is turned clockwise. When the control is fully clockwise, dynode voltage is between 1000 and 1100 volts; operation at this voltage is quite noisy.

FOUR SAMPLE AND CELL HANDLING TECHNIQUES

A cell which is positioned in the light path of a spectrophotometer becomes an integral part of the instrument's delicate optical system. It will be understood, therefore, that cell handling and treatment in general must be conducted with the same care and respect given any optical component.

It is for this reason that Beckman provides the distinctive polyethylene box for rectangular cells, as both a shipping container and a storage safeguard. Keeping cells in the box helps forestall damage from dust and other contaminants.

The following notes cover handling of cells:

a. Cleanliness of cells, especially the optical surfaces which are placed in the light path, is of paramount importance. Never touch the optical surfaces; natural skin oil or perspiration develop smudges and

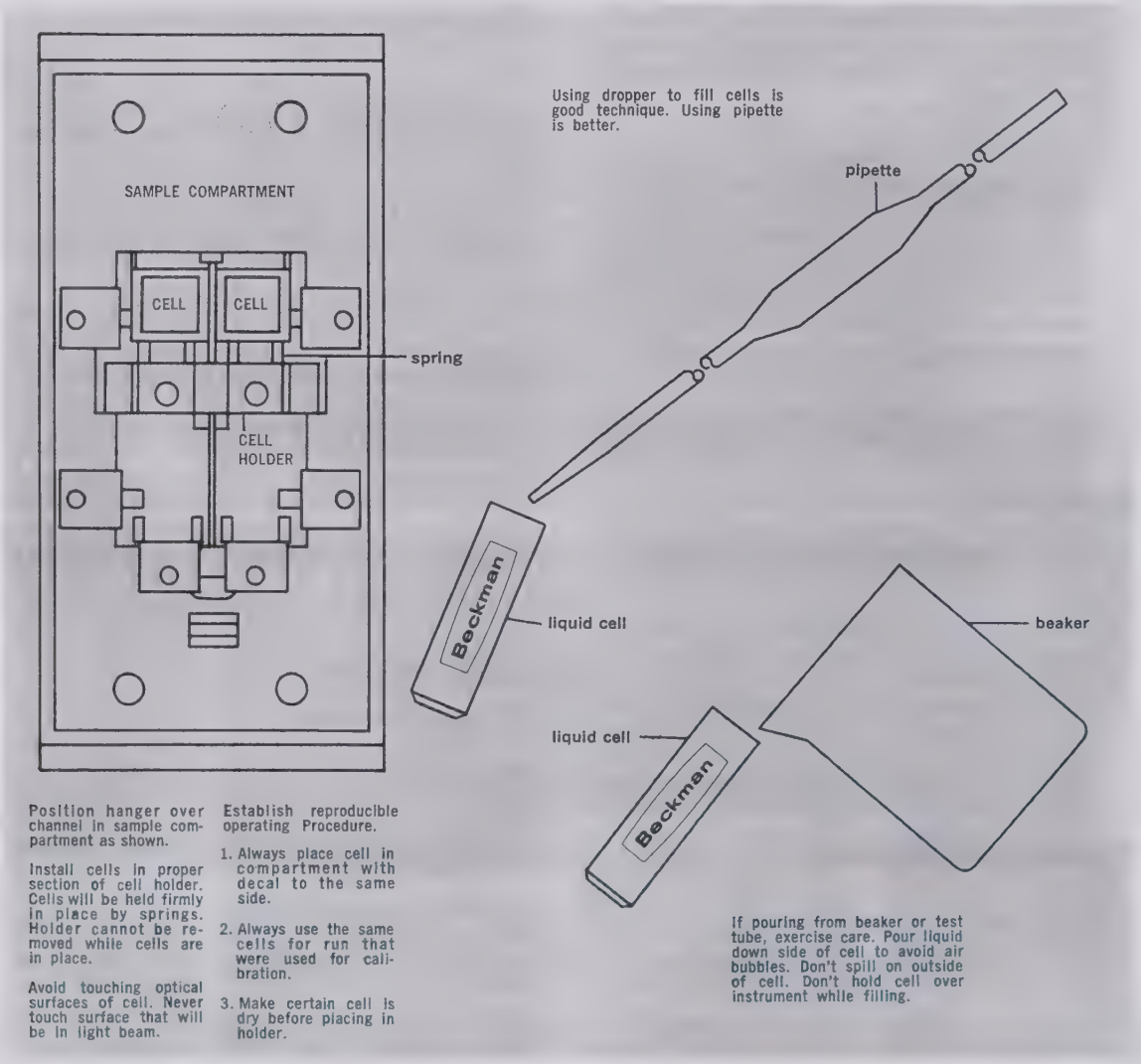

SAMPLE COMPARTMENT
CELL
CELL
spring
CELL HOLDER
Position hanger over channel in sample compartment as shown.
Install cells in proper section of cell holder. Cells will be held firmly in place by springs. Holder cannot be removed while cells are in place.
Avoid touching optical surfaces of cell. Never touch surface that will be in light beam.
Establish reproducible operating Procedure.
1. Always place cell in compartment with decal to the same side.
2. Always use the same cells for run that were used for calibration.
3. Make certain cell is dry before placing in holder.
Using dropper to fill cells is good technique. Using pipette is better.
pipette
Beckman
liquid cell
beaker
liquid cell
Beckman
If pouring from beaker or test tube, exercise care. Pour liquid down side of cell to avoid air bubbles. Don't spill on outside of cell. Don't hold cell over instrument while filling.

Figure 8. Cell Handling Techniques

give rise to localized absorption or light reflection characteristics.

b. By the same token, scratches on the optical surfaces also absorb or reflect light, which may cause serious errors in analyses.

c. Contamination — not, of course, scratches — may be removed by rinsing the cell with distilled water. If that fails, soak the cell for a few minutes in a mild sulfonic detergent solution, or in solvent in which the sample is soluble. When required, a stronger cleaning agent involves soaking in an acid-alcohol solution (a 50-50 solution of 3N HCl and alcohol). **Never** use hot, concentrated acids or alkalies, abrasives, or any agents which would etch the polished optical surfaces.

CAUTION

Avoid using ultrasonic cleaners. Possible cell damage may result.

d. Cells must be dry outside, before insertion in the sample compartment.

e. When filling cells, it is a prudent practice to keep them away from possible spillage into the sample compartment. Figure 8 graphically portrays various cell handling methods.

f. A small Beckman trademark label is fused on a non-optical surface of most cells. The label helps facilitate repeatable orientation of a cell in the sample compartment. Cells are properly oriented when they are faced in the same direction with each use. Demountable flow cells, gas cells, and 1 mm rectangular cells, do not have the position reference label, but may be readily marked on a non-optical surface to serve the same purpose.

4.1 SOLVENT

Liquids used as solvents in spectrophotometry should be chemically inert to the material being analyzed. They also must be transparent over the spectral range of the investigation. Figure 9 tabulates some widely used solvents for both the visible and ultraviolet range.

It is desirable that the solvent used produce a flat, straight-line recording at high transmittance, or a steady, single-value meter reading. However, some solvents may exhibit absorption characteristics which will limit their useful range. Every solvent must be tested for impurities before use. Peaks, other than the usual absorption edge profiles suggest the presence of impurities which either dictate additional purification steps, or use of another solvent.

SOLVENT	WAVELENGTH RANGE IN MILLIMICRONS	COMMENTS
Ethyl Alcohol	210-800	Very valuable; dissolves the great majority of organic compounds. Use good absolute alcohol, not dried by azeotropic distillation (which leaves traces of benzene).
Isopropyl Alcohol	210-800	Same properties as Ethyl Alcohol. Traces of water and acetone impurities.
Ether	220-800	Very useful; rapid evaporation dictates use in sealed, one-piece cells.
Cyclohexane n-Hexane n-Heptane Iso-Octane n-Pentane	210-800	Saturated hydrocarbons; excellent when pure. Pour through chromatographic column filled with silica gel to remove traces of benzene.
Acetonitrile N, N-Dimethylformamide	200-800 270-800	Widely used in UV work.
Chloroform	245-800	Dissolves materials not readily soluble in alcohol; contains a minimum 1% alcohol as stabilizer.
Carbon Tetrachloride Water, distilled	265-800 200-800	Limited to water-soluble samples. Use freshly-boiled water to avoid air bubbles.

Figure 9. Solvents

For purposes of clarity, the following technical descriptions of the theoretical design and specific functions of these spectrophotometers are given separately for the Model DB and the Model DB-G.

5.1 OPTICAL SYSTEM, MODEL DB

The optical diagram of the Model DB is illustrated in Figure 10. Radiant energy from the tungsten lamp or hydrogen discharge lamp is directed by the diagonal entrance mirror through the entrance slit to the collimating mirror.

The collimated beam of energy is refracted at the front surface of a fused silica prism, travels through the prism, is then reflected back through the prism by the aluminized back surface, and is again refracted at the front surface. Desired wavelengths are selected by rotating the wavelength dial, which determines the angular position of the prism in the energy path.

The dispersed beam is again directed to the collimating mirror, and the selected wavelength is focused on the exit slit of the monochromator. Dispersion data are shown in Figure 12. The beam, now a narrow band of energy, passes through the exit slit and exit lens and is directed alternately by the vibrating mirrors in the beam switching mechanism (at about 35 cycles per second), through the sample and reference cell paths. Any absorption by sample reduces the energy in the sample path in comparison to that in the reference path.

Finally, the energy reaches the detector mirror and is focused upon the photomultiplier detector. The Models DB and DB-G are shipped with the 1P28A photomultiplier tube as standard. For analyses requiring determinations at longer wavelengths (above 700 mμ), the accessory R136 tube may be substituted.

5.2 OPTICAL SYSTEM, MODEL DB-G

The optical diagram of the Model DB-G is shown in Figure 11. In place of the conventional Model DB prism, the Model DB-G employs a precision replica grating as the dispersive element. The grating has 1200 lines per millimeter, is blazed at 250 millimicrons, and is used only in the first order. The dispersion curve for the grating instrument is shown in Figure 12.

In the entrance beam, between source and entrance mirror, is mounted a four-position filter wheel. In one position, there is an opening through which the entrance beam passes unrestricted. The opening is positioned in the beam in the region from 185 to 300 millimicrons. In the other three positions are mounted filters that filter the entrance beam and transmit only specific regions of the spectrum. A violet filter (Corning CS 7-54) is in the beam from 300 to 350 millimicrons, a clear filter (Corning CS 0-54) is in the beam from 350 to 590 millimicrons, and a yellow filter (Corning CS 3-68) is in the beam from 590 to 1000 millimicrons. The transmission characteristics of the three filters are shown in Figure 13.

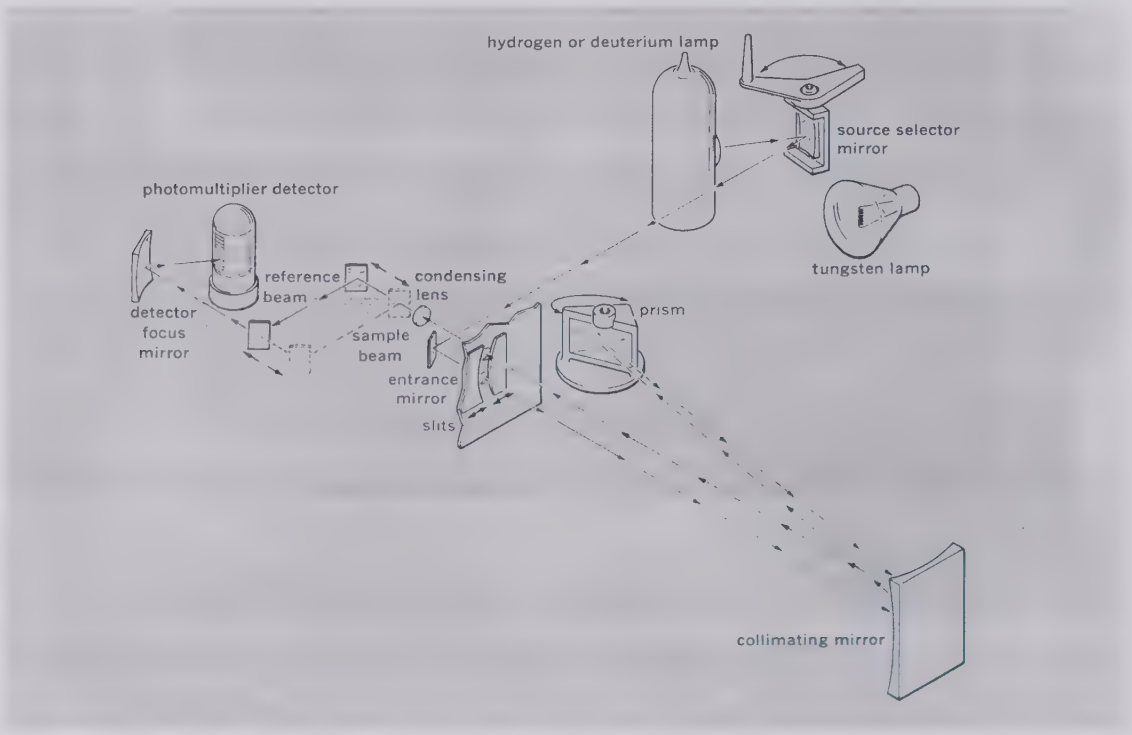


Figure 10. Optical Diagram of Model DB

The filter wheel is rotated automatically to the four positions by a stepping switch that is linked mechanically to the wheel through a gear arrangement. The stepping switch is rotated by a solenoid which is energized at the correct filter-change positions (590, 350, 300 and between 1000 and 185 millimicrons) through microswitches that are activated by cams mounted beneath the wavelength dial. (Note: a small discontinuity or "spike" will be evident in recorded spectra at the filter-change positions.)

A logic circuit provides for correct positioning of the filter wheel when scanning either upscale or downscale.

Except for the grating, filter wheel, and slit curvature, the optical system of the grating instrument is identical to that of the Model DB prism instrument.

5.2.1 SLIT SYSTEM

The slits are mounted on a pair of reed parallelograms, Figure 14. Opening motion applied to the slit follower arm through linkage to the concave defining jaw is also applied to the convex defining jaw through the slit links and pivot arm. Initial tension in the reeds provides the required closing force when motion is reversed.

The exit slit is positioned directly above the entrance slit, and a single set of slit jaws determines the width of both. The two slit jaws are mounted on flexible reeds and are linked together so that bilateral motion is assured.

Energy at the detector will be affected as a square function of the slit width. Either of two slit cams mounted coaxially with the wavelength cam will program the slits to compensate for non-uniformity of the sources and detector as a function of wavelength. In the Model DB, the two cams differ by the square root of 2 in slit opening or a factor of 2 in energy.

The Slit Program Selector positions the cam follower on the smaller of the two cams for NARROW SLIT function, and on the larger cam for the MEDIUM function. The Manual Slit Adjust permits manual adjustment of the slits from the closed position to two millimeters maximum, when the Slit Program Selector is in the MANUAL position.

On the Model DB-G, the two cams function in position 1 for the 1P28A photomultiplier, and in position 2 for the R136 photomultiplier.

5.3 ELECTRONIC SYSTEM

Electronically, the circuitry of the prism Model DB is applicable in most major respects to the grating Model DB-G. The grating instrument, however, has an additional circuit that includes microswitches and a solenoid-operated stepping switch for actuation of the filter wheel. Figures 37 and 38 are the schematic and pictorial wiring diagrams, respectively, for both spectrophotometers.

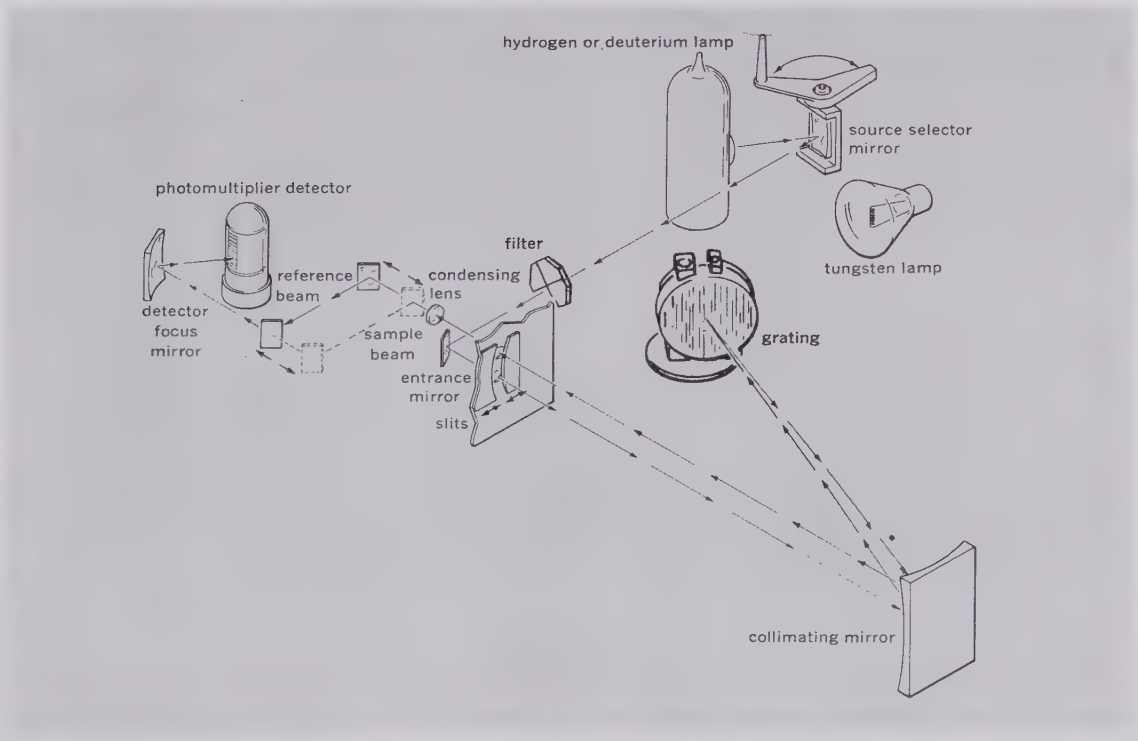


Figure 11. Optical Diagram of Model DB-G

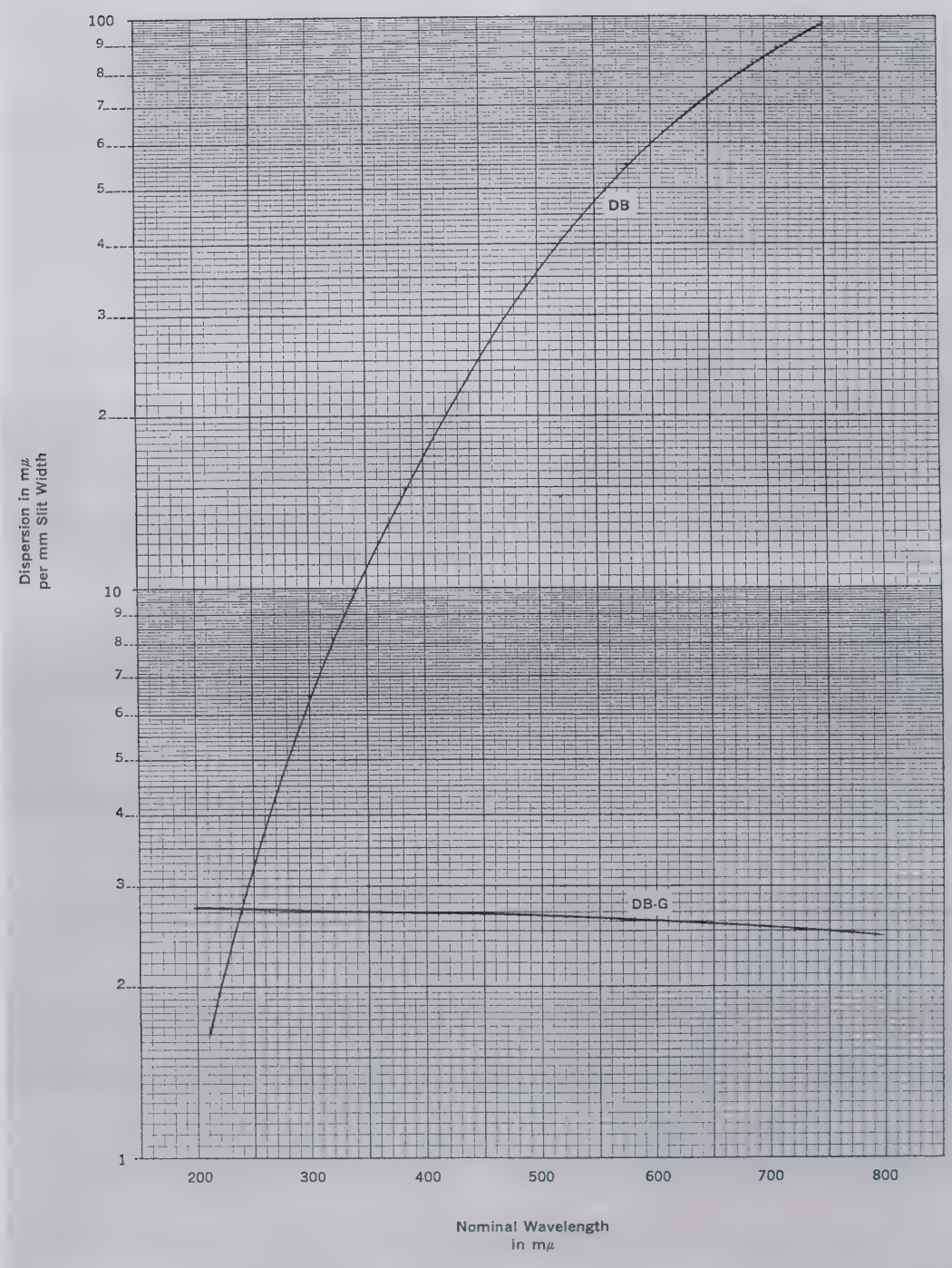


Figure 12. Dispersion Curves of Models DB and DB-G

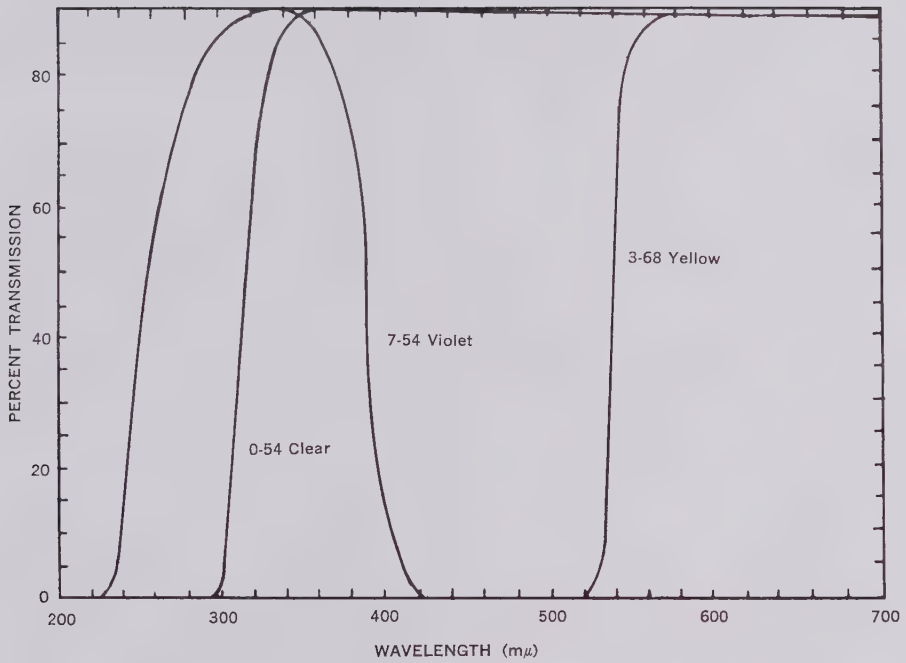


Figure 13. Transmission Characteristics of Filters in Model DB-G

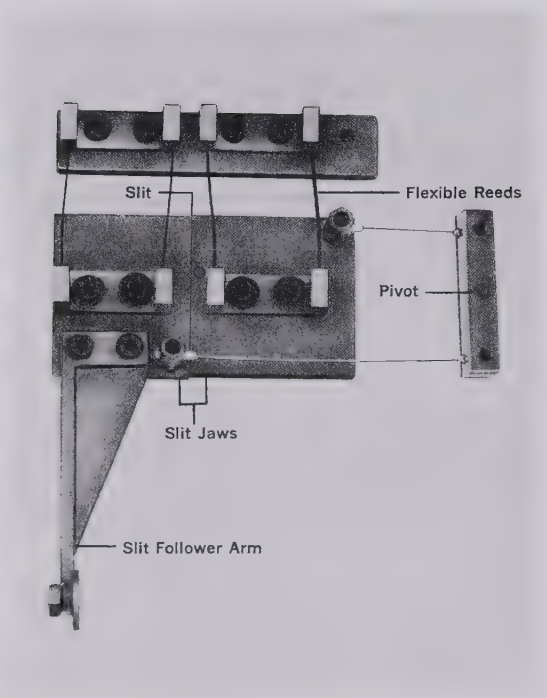


Figure 14. Slit System

The circuitry is discussed in detail in the following paragraphs:

1. PHOTOMULTIPLIER — After leaving the beam-switching assembly, where monochromatic energy of the selected wavelength has been passed alternately through the sample and reference cells by a self-resonating reed system, the alternating pulses of energy fall on the photocathode of a 1P28A photomultiplier.

   Electrons emitted by the cathode surface, are attracted to the first dynode by its more positive voltage, and on striking the first dynode, cause secondary electrons to be emitted, which, in turn, are attracted to the second dynode by its higher positive potential. Thereafter, each impinging electron causes additional secondary electrons which impinge successively on each of the nine dynodes of increasingly positive potential. Finally, at the anode of the tube, a current gain of approximately 100,000 is effected.

   The dynode voltage, varying inversely with the energy of the reference path (in double-beam operation), is divided equally among the dynodes.

   A 1P28A multiplier phototube is standard equipment with these instruments, but use of the accessory R136 tube gives an extended response in the red region above 700 mμ. Figure 15 illustrates sensitivity ranges of the two tubes.

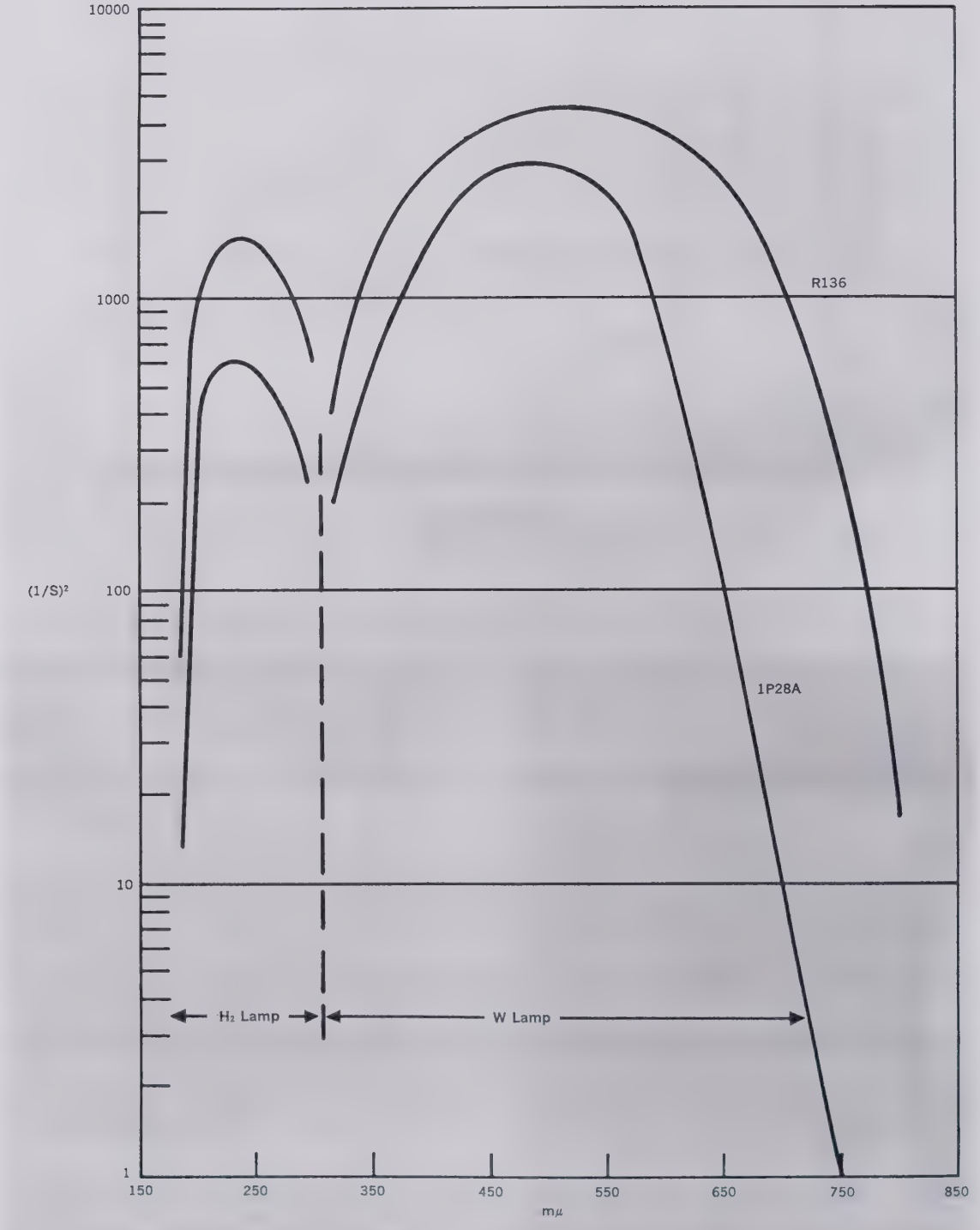


Figure 15 Relative Photomultiplier Tube Sensitivity

2. SIGNAL AMPLIFIER — The signal amplifier, see Figure 37, consists of a pentode amplifier stage and a cathode follower output stage. V7 is used in a region where its open gain loop is more than 800. It employs four feedback loops that establish the operating point and stabilize the gain. Plate feedback, C10 and R34, effectively increase the plate load impedance and open loop gain of V7; this feedback always is less than unity from degeneration in the cathode follower. Compensation for tube differences is provided by screen feedbacks R37, R38 and C12. Screen voltage is established automatically, regardless of the transconductance of V7. When the multiplier phototube is overloaded with unchopped radiation, C8 and R30 prevent the amplifier from becoming "blocked." R39, R40, and R33 stabilize the closed loop gain to about 20.

3. CIRCUIT OPERATION — Electrons collected on the anode of the photomultiplier produce a negative-going voltage on passing through R31. This voltage is applied to the grid of V7 through C9, decreasing the current through V7. The plate of V7 and grid of V3B go in a positive direction when the current is reduced in R35. The cathode of V3B follows the grid. This voltage is divided by R39 and R40 and the divided portion is applied to the grid of V7 through R33 to stabilize the gain of the amplifier to approximately 20. C13 couples the amplifiers to the regulator or to the meter circuit depending on the position of the signal switch. CR3 clamps the cathode voltage on C13 when the cathode of V3B is in the negative portion of the cycle.

4. OUTPUT SIGNAL SWITCH — The output signal switch is synchronized with the beam-switching circuit so that it switches the reference component of the amplifier output to the automatic reference-standardizing circuit and switches the sample components of the amplifier output to the meter circuit.

   The output signal switch is a magnetic switch with mercury-wetted contacts, hermetically sealed in a hydrogen atmosphere. The switch forms the armature of its activating coil and both are enclosed in a steel envelope. Capillary action draws the mercury from a reservoir in the bottom of the glass capsule to wet the switch surfaces.

5. METER CIRCUIT — When the cathode of V3B is at a minimum signal, this voltage is clamped on C13 by diode CR3. When the cathode of V3B is at its maximum positive voltage, the clamped voltage on C13 plus the residual voltage on C14 must equal this maximum voltage. If not, CR4 will conduct, resetting the voltage on C14. CR4 permits peak reading of the sample signal. R41 filters the noise on charging C14. C14 maintains the current through the meter during reference and clamp portion of the cycle. R42 and R43 (100% Adjust) limit the current through the meter. R42 is adjusted for 100%T when the transmittance of the reference and sample beams are equal.

   Meter current through R73, and R74 serves as a voltage source for an external recorder. This voltage is adjustable from <95 to >105 mv by R73. Switch S10, ganged to R73, permits the recorder load resistor to be switched out so that the accessory scale expander may be used after the jumper wire, Paragraph 3.2, is clipped.

   C25 is a filter condenser to filter current pulses through the meter. Switch S-2C, a section on the Power Control Switch, shunts the meter when the switch is at the OFF and IDLE positions. C15 is an additional filter condenser added when S-1C, a section of the Operation Switch, is in SINGLE (FLAME) operating mode position.

6. REGULATOR — The spectrophotometer measures the percent-T relationship of the sample and reference signal at an 85-volt level. This is accomplished by comparing the amplitude of the reference signal to a fixed voltage from the power supply. The difference is amplified and used to bias the control tube of the dynode voltage regulator. The control tube (6EM5) and photomultiplier divider share the voltage of a floating power supply. The relative voltages appearing across these elements are determined by the bias of control tube.

   When the reference signal appears on C13, it is switched to the dividing network C3, R10 and R11. R12 couples the divided portion to the grid of V2B where it is compared with the reference voltage appearing on the cathode of V2B. R5 and R6 divide the voltage of V4 in the same ratio as the reference signal divider, R10 and R11, so the reference signal will be regulated at an 85-volt level within the bias of V2B. The 85-volt level was selected so the bias stability of V2B and contact potential of CR3 would be small compared to the linearity and stability of the instrument. If the divided portion of the reference signal is equal to the reference voltage of the cathode, V2B will conduct, resetting the voltage of C4 through integrating resistor R66. The cathode voltage on V2B plus the voltage on C4 is coupled to the grid of V5 through R14. The voltage divider R18, R19 and R20 establishes the operating point of V5. The cathode voltage on V2B plus the voltage on C4 minus the voltage across R20 is the bias voltage on V5. The photomultiplier divider R21 through R29 is the load resistor for V5. Thus, the floating power supply is shared by V5 and the dynode resistors R21 through R29.

   If the bias of V5 is decreased by an increase in the voltage on C4, the current through V5 will increase; this increased current flowing through R21 through R29 will increase the voltage across the dynode resistors. The photocathode will be negative because of the location of the ground point in the plate circuit of V5.

CR1, C6, C7 and CR2 with the shielded winding of T1, is a half-wave voltage-doubling power supply for the control stage V5. The double Faraday shield around the winding of T1 is to prevent capacity coupling of 60-cycle and line transients to the high voltage supply.

R14, C5 and R17 is a feedback network that serves two purposes: transients originating in the high voltage supply are coupled to the grid of V5, their effect on the dynode voltage is reduced by the gain of V5; also any change in the voltage on C4 is degenerated by feedback through C5 and R17. The effective capacity of C5 is increased by the gain of V5 by its position in the circuit. Thus, the time constant of C5 and R14 is approximately equal to the sustaining time constant of R13 and C4. The time constant R13 plus R66 and C4 maintain the voltage on the grid of V5 during the absence of the reference signal.

7. CIRCUIT OPERATION WITHOUT REFERENCE SIGNAL — When there is no reference signal across R10 and R11, the grid of V2B is connected to ground through R11. The cathode is at the divider voltage of R5 and R6; therefore, V2B is cut off. The voltage on C4 slowly increases by current through R13 and R66. This change in voltage is applied to the grid of V5 where it increases the current through V5. The increased current through the dynode resistors R21 through R29 increases the voltage across the feedback network R17, C5 and R14. When R17 is adjusted properly, the feedback voltage will compensate for the change of voltage on C4 with minimum change in dynode voltage.
8. CIRCUIT OPERATION WITH REFERENCE SIGNAL — When the reference signal first appears across the divider R10 and R11, it will be large enough to cause V2B to conduct. This, in turn, resets the voltage on C4 by discharging C4 through R66. The reduced voltage of C4 applied to the grid of V5 reduces the current through V5. The reduced voltage on the dynode resistors of the photomultiplier reduces the current gain of the photomultiplier and decreases the amplitude of the reference pulse. This action continues until the amplitude of the reference pulse is again equal to 85 volts. At this time, C4 is "reset", V2B is near "cutoff" and the circuit is ready to "coast" during another sample pulse.
9. SINGLE-BEAM OPERATION — In single-beam operation, all components beyond V2B operate in the same manner as in double-beam or reference control operation. When the Operation Switch is in FLAME position, for single-beam operation, the following circuit changes are made: The grid of V2B is connected to ground through R12; the cathode of V2B is connected to the junction R7 and R15. C15 is connected across the meter circuit for additional filtering. With the grid of V2B returned to ground through R12 and the cathode connected to 85 volts through R7, V2B will remain cutoff until C4 is charged through R13 and R66 to the point where the conduction of V5 increases the voltage across R21 through R29.

   The dynode voltage is applied to the divider R16, R15, and R7. When this current is sufficient to produce 85 volts across R7, the cathode voltage will approach the grid voltage and V2B will conduct. V2B will continue to regulate the dynode voltage at this level until R7 is changed. If R7 is decreased, the dynode voltage will be increased, and conversely, if R7 is increased, the dynode voltage will be regulated at a lower level.
10. POWER SUPPLY — The power supply consists of a full wave rectifier, condenser input filter with conventional series regulator for regulated DC of 225 volts. Transformer T2 includes two 6-volt windings so the filaments may be referenced to a d.c. voltage near their cathode potential and a 5.5-volt winding with full wave rectifier and condenser input to filter the voltage to the tungsten source. Power Control Switch S2 has five sections for the following functions: section 2A connects 115 volts a.c. to transformers T1 and T2 in the last three of four positions; section 2B connects 115 volts a.c. to the tie point TP1 in the fourth or scan position of S2 for the wavelength drive motor; section 2C connects a short across the meter in the first and second (OFF and IDLE) positions of S2; section 2D connects B+ unregulated to the cathode followers V8B and V9 in the third and fourth (ON and SCAN) positions of V2. Section 2E closes the circuit to scan receptacle P5 in the fourth or SCAN position.
11. REGULATED SUPPLY — The 800-volt center tapped winding of T2 supplies 400 volts RMS to each plate of the full wave rectifier V1. The d.c. voltage appearing on the cathode of V1 is filtered by C1A and supplies unregulated d.c. voltage to the cathode followers V2B, V8B, V9 and filament reference divider R45 and R46. V3A is a series regulator shunted by R2, to increase its current capacity, and controlled by V2A through load resistor R1.

    V2A is a voltage amplifier with its cathode fixed at 85 volts by V.R. tube V4. R8 and R9 form a divider for the grid of V2A and determine regulating point of B+. C2 and R4 increase the high frequency feedback and thus reduce the ripple in regulated B+.
12. OPERATION — As the regulated voltage appearing at the junction of dividers R8 and R9 increases toward 85 volts, the current through V2A increases. This increased current through R1 lowers the plate voltage of V2A as well as increasing the bias on series regulator V3A.

    The increased bias of V3A increases the voltage drop across the tube, correcting for the change in B+ regulated. The circuit operates in the same manner for ripple and transients with

the exception of the regulating divider. Ripple and transients are divided by C2, R4, and R9; therefore, the feedback is a function of the impedance which in turn is a function of the frequency of the transient. The regulator will maintain B+ regulated to better than 1%.

13. VIBRATING MIRROR SYSTEM — The vibrating mirror system is a four bar linkage with pivots of gold-plated spring steel reeds. A silicon-steel armature is attached to one of the side members. The armature passes through a coil form which has polarizing magnets molded in. When a current passes through the coil, the flux induced in the armature bar reacts with the polarizing magnets and displaces the mirror system.

    A vane, attached to the linkage, interrupts a light beam illuminating a cadmium selenide cell, producing a signal in phase with the vibrating mirror system. This signal is amplified and coupled to the cathode follower with the driving coil in the cathode circuit. Thus, the mirror system is driven at resonance with simple harmonic motion.

    The amplitude is limited by another vane which uncovers a second cadmium selenide cell, illuminating it at full amplitude. This signal is coupled by means of a bridge circuit to decrease the driving signal, regulating the amplitude.

14. AMPLITUDE CONTROL DESCRIPTION—A photosensitive cadmium selenide cell (CD1) is illuminated by a neon bulb (12). An opaque vane attached to one leg of the linkage is positioned between the neon bulb and sensitive area of CD1, interrupting half of the light when the linkage is at rest. Moving the linkage in one direction increases the illumination, decreasing the resistance of CD1. R51 and CD1 form a voltage divider across an electrical bridge with legs R49 and a thermistor on one side and CD2 and R52 bypassed by C18 on the other. When the resistance of CD1 decreases, the voltage at the junction of CD1 and R51 decreases. This voltage is coupled to the grid of V8A by C17 and R53, decreasing the grid voltage.

    Decreasing the grid voltage decreases the voltage drop across plate load resistor R55. This positive-going voltage is shifted in phase by R56 and C21, then coupled to the grid of cathode follower V9 by C23, grid limiter R26 and grid return R60. The cathode of V9 follows the grid, increasing the current through the driving coil K2. Condenser C1B blocks the direct current through the coil, preventing overheating. Resistor R63 is a biasing resistor in series with resistor R58 to form a d.c. return. When the linkage reaches an extreme position, the signal is reversed and the mirror system is driven in the opposite direction. When the system reaches full amplitude, a vane uncovers CD2 illuminated by neon bulb 13 in one extreme position. Thus CD2 acts as a rectifier, increasing the voltage drop across R52, filtered by C18. Raising the voltage at the junction of R52 and CD2 decreases the voltage across CD1 and R51, decreasing the driving signal.

    Potentiometer R49 serves as an amplitude control by setting the proper voltage across the bridge. A thermistor compensates for the temperature coefficient of CD2.

15. DEMODULATOR DRIVING CIRCUIT—Mercury relay K1 is driven by the same signal that drives the bridge, switching the sample and reference signals in phase with the vibrating mirror system.

    The signal at the plate of V8A is shifted in phase by potentiometer R64 and C20. This signal is again shifted in phase by R57 and C22, then coupled to the grid of cathode follower V8B by C24 and grid return R61. The coil K1 is driven by the cathode with C1C blocking the d.c. R65 is a biasing resistor in series with R59, forming a d.c. return.

    The switching point is adjusted by potentiometer R64, while interchanging connections B-B will provide 180° phase change. The phasing adjustment is described in Paragraph 7.7.

SIX FUNDAMENTALS OF SPECTROPHOTOMETRY

Absorption spectrophotometry is based on the observation and comparison of absorption spectra. The absorption spectrum — a curve showing the amount of radiant energy absorbed at each wavelength — is a characteristic property of many chemical compounds; each such chemical compound has its own absorption spectrum. Basically, the spectrophotometer provides absorption data to assist in qualitative and quantitative analysis.

The following paragraphs discuss some commonly encountered phenomena of spectrophotometry.

6.1 TRANSMITTANCE

Transmittance (T) is the ratio of the monochromatic light transmitted by a sample (P) to the energy incident upon the sample (P_o). Both incident and transmitted radiant energy must be obtained at the same wavelength and with the same spectral slit width.

Figure 16 illustrates this measurement which is further explained by the equation:

$$T = \frac{P}{P_o} = 10^{-abc} \quad \text{or} \quad \%T = \frac{P(100)}{P_o}$$

P, P_o = transmitted and incident light intensity.
a = absorptivity, a property of the sample.
b = cell path
c = concentration

It is customary to consider the transmittance of sample as the ratio of the light transmitted by the cell plus sample to the light transmitted by some arbitrary standard. This standard may be the cell filled with the liquid in which sample is to be dissolved; or it may be air, or other arbitrarily-selected substance. Since the transmission of this standard is not necessarily 100 percent, it is necessary to specify the standard with which the sample is compared.

6.2 ABSORBANCE

Absorbance (A) is the negative logarithm of the transmittance: $A = -\log_{10} T$; $T = \log_{10} 1/T$ (T is expressed as a decimal fraction, not in percent). As with transmittance measurements, the standard with which the sample was compared should always be included with the absorbance data, since the absorbance of the standard is not necessarily zero.

6.3 SPECTRAL SLIT WIDTH

Spectral slit width is the total range of wavelengths emerging from the exit slit, neglecting stray light and spherical aberrations. See Figure 17. Spectral slit width is important to the spectroscopist because it indicates the purity of the radiation used for a transmittance measurement. Spectral slit width equals 2 times the dispersion in mμ/mm times slit width in millimeters.

6.4 EFFECTIVE BANDWIDTH

Effective bandwidth is the span of wavelengths emerging from the exit slit, whose end wavelengths have half the energy of the central wavelength. It is expressed in millimicrons.

Figure 16. Transmission of Light Through Sample

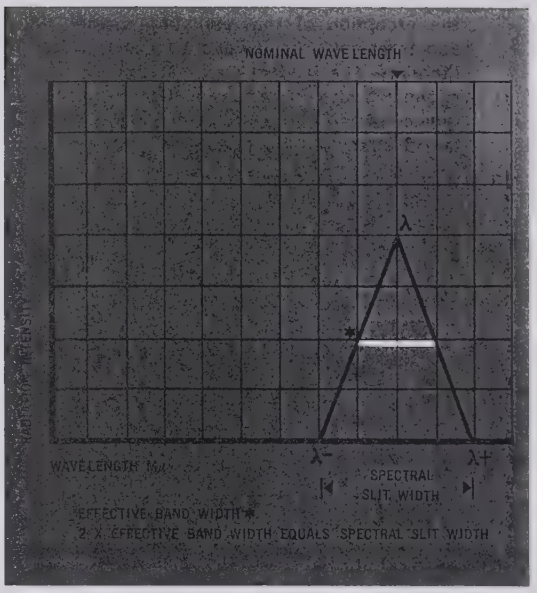


Figure 17. Spectral Slit Width and Effective Bandwidth

6.5 RESOLUTION

Resolution is defined as the minimum spacing of two adjacent lines of equal intensity at which it still is possible to detect the two lines. It also is defined as the observed half bandwidth of an emission line having essentially infinitesimal width. Essentially, resolution is the natural line width modified by the slit function of the spectrophotometer. A demonstration of the practical resolution of the Model DB is given by the doublet and triplet emission lines of mercury reproduced in Figure 18. The transmission spectra of benzene (Figure 19) and of didymium filters (Figure 20) demonstrate further the high resolution provided by the instrument. These spectra were recorded with a Model DB and Beckman (5-Inch) Laboratory Potentiometric Recorder. Note that resolution is affected greatly by operating parameters, the most significant of which are scanning speed and slit width.

Figure 21 illustrates spectra obtained with the Model DB-G.

6.6 STRAY ENERGY

Stray energy is extraneous light which reaches the phototube at wavelengths which do not correspond to the wavelength scale setting. The effect is to decrease the apparent absorbance of an absorption band and, if sufficiently high, to cause deviation from beer's law.

6.7 BANDWIDTH

The light emerging from a monochromator with a continuum source does not consist of a single wavelength but of a group of wavelengths. If the light emerging from the exit slit were examined in detail and its intensity plotted as a function of wavelength,

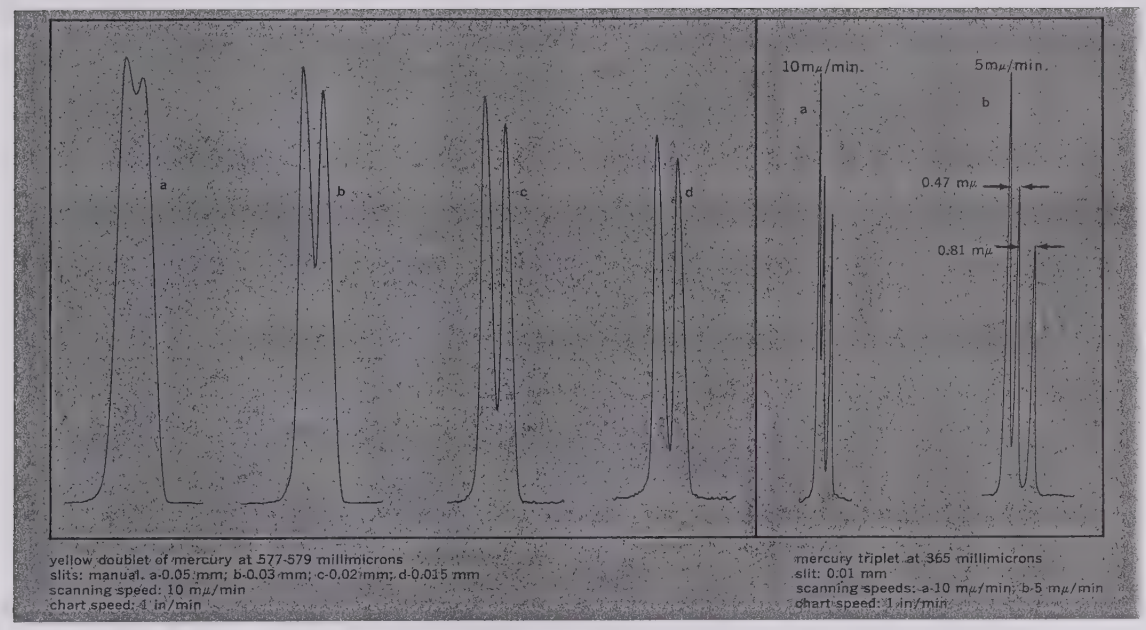


Figure 18. Resolution Demonstrated by Mercury Vapor Emission Spectra (Model DB)

a curve would result similar to that in Figure 17. The nominal wavelength is that wavelength which corresponds to the peak of the curve. The curve in Figure 17 is an idealized one that would be obtained with a perfect optical system. In practice, unavoidable aberrations result in the effective widening of the slit image, and thus the triangle shown should be slightly rounded at the top and bottom.

In the Model DB, the dispersion of the silica prism — its separation of light into component wavelengths — is nonlinear with wavelength. For example, two spectral lines whose wavelengths differ by 10 millimicrons in the blue region, are separated (in the dispersed beam) by much greater physical distance than a corresponding pair of spectral lines in the red region. Conversely, therefore, any given slit width will pass a much wider band of wavelengths in the red range than in the blue.

In the DB-G, dispersion of the grating is very nearly a linear function of wavelength. Any given slit width, therefore, will pass nearly the same band of wavelengths in the red as in the blue.

In order to achieve true transmittance readings, peaks should be resolved completely. The apparent transmittance will depend upon the slit width and will include such influences as the shape and slope of the transmittance curve within the band being transmitted and the variation of the transmittance of the optical system with respect to wavelength. It is usually easy to determine if these effects are significant by increasing or decreasing the slit width until no further change in transmittance is evidenced. Whenever very reliable values must be obtained, the narrowest possible slit width should be used con-

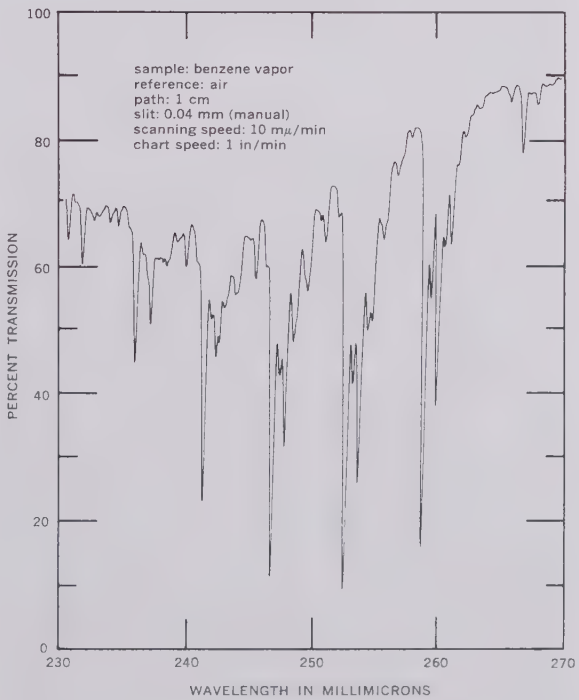


Figure 19. Transmission Spectrum of Benzene Vapor (Model DB)

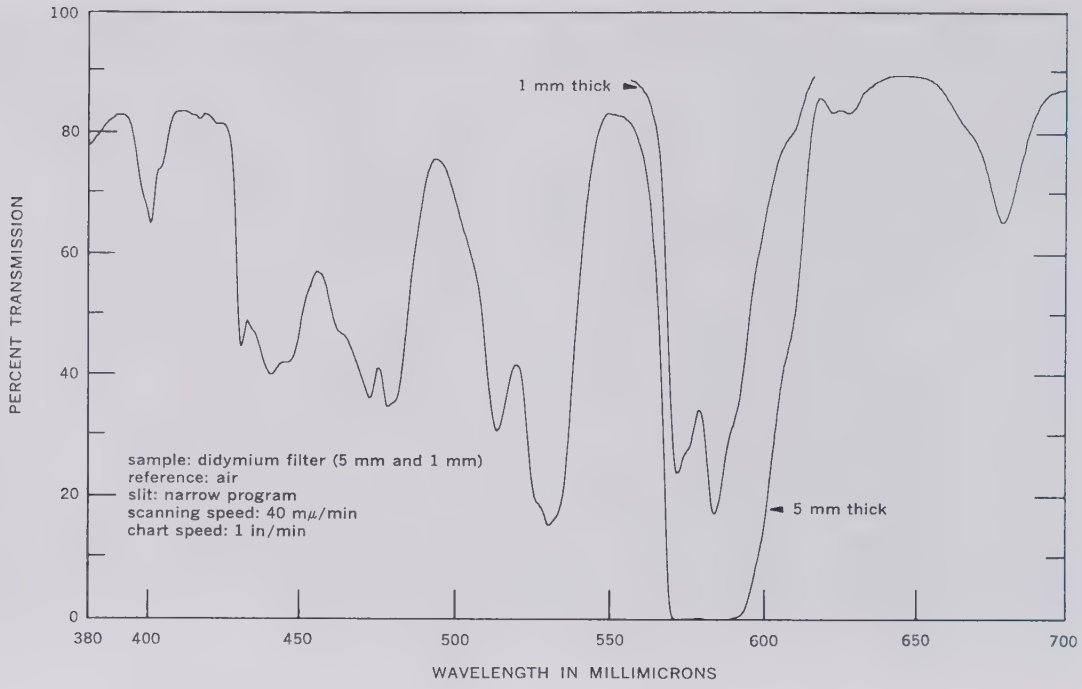


Figure 20. Transmission Spectra of Didymium Filter (Model DB)

sistent with an acceptable signal-to-noise ratio, and a check involving change of slit width should be made.

6.8 CALCULATION OF EFFECTIVE BANDWIDTH

To calculate bandwidths, it is necessary to know the dispersion of the instrument in millimicrons per millimeter of slit width at the wavelength being used, the actual slit width being used, and the effective widening of the image by diffraction effects in the optical system. The effective bandwidth is proportional to the width of both the entrance and exit slits.

Since, in both of these spectrophotometers, the slit widths are equal, the effective bandwidth is the product of linear dispersion and slit width (mechanical slit width plus effective widening).

The effective bandwidth, due to strictly geometrical considerations, is $\Delta\lambda_S = JS$.

J is reciprocal dispersion in mμ/mm

S is width of slit mm.

This formula for effective bandwidth disregards the effects of slit diffraction.

In the wavelength range of the Model DB and DB-G, these diffraction effects are very small compared to the slit widths normally used. As an example, diffraction effects should be considered only when the mechanical slit width approaches a value equal to the diffraction widening. In monochromators such as the Model DB and DB-G, these slit widths are approximately figured by the formula $S_d = 10\lambda$. Considering one wavelength, 800 mμ, where the diffraction effects will be the greatest, the formula gives a slit width of 0.008 mm. This slit width is less than the 0.01 mm minimum slit width recommended for use on the DB. It is also much less than is practical due to energy available in this region. In the vast majority of normal uses, diffraction effects may be ignored.

Like the prism instrument, the grating instrument is provided with a slit cam programmed for use with the 1P28A photomultiplier tube. In addition, the grating instrument has an auxiliary slit cam programmed for use when the instrument is equipped with the accessory R136 photomultiplier tube which has a modified S10 response. This accessory photomultiplier tube (identical physically to the 1P28A) responds in the range from 190 to 850 millimicrons (as opposed to the 1P28A photomultiplier which has little response above 700 millimicrons), and has a response peak at 430 millimicrons.

On the Model DB-G, the Slit Program Selector is turned to position 1 when selecting the 1P28A cam, and to position 2 for the R136 cam. The MANUAL position permits manual slit adjustment with the Manual Slit Adjust. On the Model DB, either NARROW SLIT or MEDIUM positions of the Slit Program Selector may be used with either photomultiplier.

6.9 ABSORPTION

All substances transmit some portions of the electromagnetic spectrum and absorb others. The color of red glass, for example, results from the fact that it absorbs light of short wavelengths, the green and

the blue, and transmits light of long wavelengths, the red and some yellow light. The concentration of the solution and its thickness will further affect the absorbance. If the absorbance is plotted against wavelength the spectral absorbance curve of the sample is obtained.

Just as each component has its own absorption spectrum, a mixture of two or more components will yield an absorption spectrum representing characteristics of all the components. The absorbance at each wavelength is the sum of the absorbances of the components of the mixture at that wavelength; the contribution of each component is proportional to the concentration and to its absorptivity at that wavelength. Absorptivity is the ratio of the absorbance to the product of concentration and pathlength, and is a wavelength-dependent property of the analyte.

6.10 QUALITATIVE INTERPRETATION

Problems involving the identification of organic components can be solved by spectrophotometric techniques through use of the matching fingerprint method. If the spectroscopist has an extensive library of absorption curves for known compounds, positive identification of the unknown is established in a very short time if the unknown spectrum matches any of the known spectra. Should the unknown spectrum not match any of the known, the negative data is still important because it restricts the field of possibilities.

6.11 QUANTITATIVE INTERPRETATION

Usually, in quantitative work, the constituents of the sample are known and it is desired to determine the concentration of one or more of them. If, however, it is necessary to decide what components are present, this information may be obtained from the history of the sample, by ordinary qualitative chemical analysis, or by comparing the spectrum of the mixture with the spectra of various pure samples as discussed above.

6.12 TRANSMITTANCE AND ABSORBANCE MEASUREMENTS

Transmittance or absorbance measurements usually are made by comparing a sample to a standard (or reference). As the standard would obviously have a transmittance of 100 percent compared with itself, it may be called the 100 percent reference. It is possible to define various standards but usually the standard is a blank, i.e., a solution identical in composition with the sample except that the absorbing material being measured is absent. In making the spectrophotometric measurement, the operator sets the instrument at 100 percent by using the 100 percent reference. The sample is then placed in the light path and its transmittance or absorbance read.

The 100 percent reference usually contains none of the absorbing substance, although in differential analysis, comparison may be made to a solution with a known analyte concentration. In the beer's law graph, the 100 percent reference will lie at zero on the concentration axis. In this instance, the 100 percent reference may be considered to be one of the series of standards used in preparing the graph.

Often, quantitative techniques are developed where the 100 percent standard contains a known concentration of the analyte. Use of such a standard allows greater measuring accuracy and precision of measurement, particularly where the samples are stable and where strong absorption bands must be used for measurement. This technique is analogous to scale expansion.

6.13 BEER'S LAW

Quantitative spectrophotometry (single component analysis) is based upon the fact that the absorbance of a substance is dependent upon its concentration. If the absorbance is directly proportional to the concentration, the system is said to obey beer's law. The absorbance of sample also is directly proportional to the length of the light path within the sample, as lambert's law shows. (In much practical spectrophotometric work, the cell length is a constant, and therefore, it cancels out in beer's law calculations). Mathematically:

$$A = abc$$

In this case, A is the absorbance, a is the absorptivity (usually in cm^2/mol, or cm^2/gm, although other units

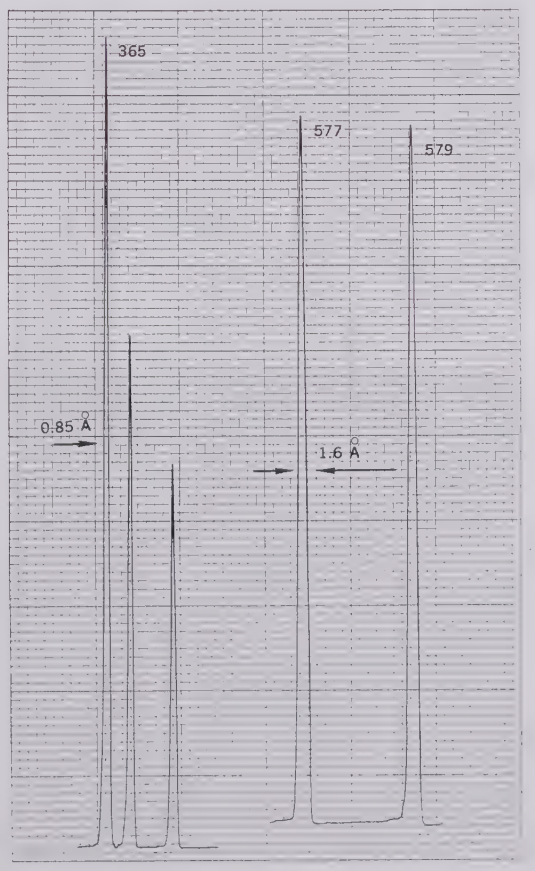


Figure 21. Resolution Demonstrated by Mercury Vapor Emission Spectra (Model DB-G)

may be used); b is the length of the light path, and c is the concentration (mass per unit volume, usually in mol/liter or gms/liter, although other units may be used).

Assuming that beer's law is obeyed strictly, it would be very simple to obtain the concentration of an unknown by simply comparing the absorbance of a known sample. Concentration of the unknown could then be readily obtained by simple proportional arithmetic.

If the absorbance of a compound follows beer's law, and the absorbance is plotted graphically versus concentration, a straight line which passes through the origin is obtained. In Figure 22 are reproduced spectra of cobaltous ammonium sulphate at five different concentrations. These spectra were obtained on a Model DB equipped with a Beckman Laboratory (Five-Inch) Potentiometric Recorder. By plotting the concentrations of the five solutions versus the peak, adherence of the absorbance of the solution to beer's law can be checked. This was done in Figure 23, utilizing the absorbance and concentration data from Figure 22. Obedience to beer's law is demonstrated by the plot.

Strict adherence to beer's law depends on conformance of sample to certain requirements: sample either must be compared with a reference in which the concentration of the absorbing compound is zero, or it must be corrected for baseline effects due to such factors as reflection loss and the like. The absorbing compound must not participate in an equilibrium in the solution which would be shifted by a change in concentration; essentially monochromatic radiation must be used for measurements; and measurements must be made at the wavelength where absorbance does not change appreciably with wavelength; that is, where resolution is not a significant factor.

However, in practical work, samples may show apparent deviations from beer's law. Apparent deviations usually are caused by chemical or physical effects. Some of the chemical effects are: association or disassociation of the molecule within the compound; solvent-solute interaction, and changes in pH and temperature. Of the physical causes, one of the main factors is the inability to obtain pure monochromatic radiation, that is, the inability to isolate a single wavelength or frequency of radiation. Also, other physical effects, such as the change of refractive index with a change in the concentration, cause deviations. Graphically, when the absorbance is plotted versus concentration, deviations are readily recognized by the fact that a straight line is not obtained.

For quantitative measurements on pure compounds, apparent deviations from beer's law may make it necessary to plot the absorbance of a series of standards (solutions containing known concentrations of the absorbing material in the sample) against their concentrations, as was done in Figure 22 for cobaltous ammonium sulphate. A slightly curved line may be obtained, as opposed to the straight line obtained in Figure 23. When the absorption spectrum of the sample has been obtained, the maximum absorbance value is taken from it. Then the concentration of the pure compound in the sample may be read directly from the curve plotted from the series of standards.

The absorbance of a mixture at a particular wavelength is the sum of the absorbances of all the components of the mixture, in the absence of solute-solvent, or solute-solute interactions.

Figure 22. Absorption Spectra of Cobaltous Ammonium Sulphate at Different Concentrations

Figure 23. Curve of Check on Beer's Law

The Models DB and DB-G are manufactured to close tolerances, and are given a rigorous series of adjustments and inspections before being shipped. Routine operation, therefore, should proceed for a long time without malfunction. Normal wear, however, will make some adjustment and eventual parts replacement necessary. Replacement information is given in the following paragraphs.

The electronic components of the instrument consist of standard, easily-available tubes. It is a recommended practice to check tube performance on an individual basis with an identical tube known to be good. This will require maintaining a spare tube stock but will reduce down-time.

Beckman part numbers for all replacement items are given in the copiously-illustrated Section Nine.

7.1 REPLACING TUNGSTEN LAMP

The 32-candlepower, 6-volt tungsten lamp emits radiation in the wavelength region between 320 and 3500 millimicrons. Below 320 millimicrons, the glass envelope begins to absorb so that the lamp cannot be used in the ultraviolet region of the spectrum. The useful life of the tungsten lamp is estimated at 2,000 hours when operated at a potential of 5.5 volts, with a current of 4.5 amperes. The life of the lamp is markedly decreased by an increase in the operating voltage.

With time, the evaporation of tungsten produces a deposit on the inner surface of the tungsten lamp and reduces emission of energy. Dark spots on the bulb indicate this condition. It is recommended that the tungsten lamp be replaced periodically according to a regular schedule. Replace the tungsten lamp with a new one as follows:

1. Disconnect power cord of instrument.
2. Remove the holding screw at the rear of the cover. (The screw may be discarded; it is provided as a shipping safeguard.) Push up and release the two quick-release latches in grooves on both sides of the instrument. Lift the cover and tilt it forward to remove it from the base.
3. Wrap cloth as a protective feature around the glass bulb of the tungsten lamp. Gently push in the lamp and twist it counterclockwise until the alignment pins slide past the keyed slots, freeing the base of the lamp.
4. Wrap cloth around the bulb of the replacement lamp. Orient the detent slots to fit projection pins of the socket. Press lamp in place and turn it clockwise until the detents lock the pins.

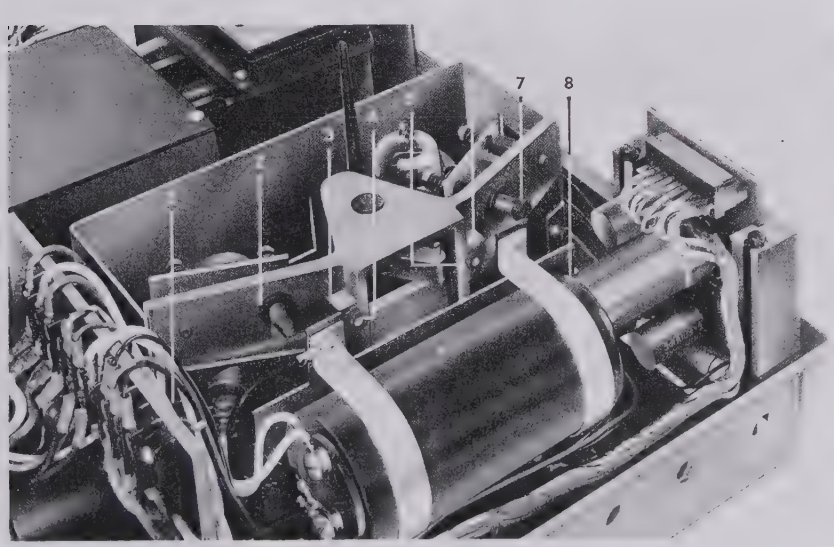
7.2 POSITIONING AND FOCUSING TUNGSTEN LAMP

When tungsten lamps are substituted, or changed in any way, major adjustments normally are not necessary. However, alignment of the lamp should be checked to make sure it is delivering maximum energy.

Operators will find it helpful to cover the sample compartment with a folded cloth to prevent stray light leaks when following alignment procedure.

The following adjustment is made with the instrument compartment cover removed, sample compartment covered as previously instructed, wavelength dial turned to 500 mμ, and Operation Switch positioned at FLAME position for single-beam operation. Gain or slit width, if necessary, are reduced successively until meter reads midscale after each step.

1. Examine the position of the entrance beam relative to the entrance port. If not centered, adjust the tungsten lamp vertical screw to center the beam vertically on the entrance port just in front of the slit diagonal mirror, Figure 24.
2. Loosen 4-40 lock screw and adjust tungsten lamp mirror screw until beam is centered horizontally on entrance slit aperture.



1. Vertical Adjustment for Tungsten Lamp
2. Focus Adjustment for Tungsten Lamp
3. Mirror Adjustment for Hydrogen Lamp
4. 4-40 Lockscrew
5. 4-40 Lockscrew
6. Mirror Adjustment for Tungsten Lamp
7. Focus Adjustment for Hydrogen Lamp
8. Vertical Adjustment for Hydrogen Lamp

Figure 24. Source Lamp Adjustments

3. Keeping the horizontal center, adjust the tungsten lamp horizontal screw (focus adjustment) for maximum energy. This adjustment is not independent of the others.
4. Tighten the lock screw in reverse order of Step 2.
5. Replace cover.

7.3 REPLACING HYDROGEN DISCHARGE LAMP

The useful operating life of the hydrogen discharge lamp should exceed 200 hours under normal conditions. The end of the useful life of this lamp is denoted by failure to start or by a rapidly decreasing energy output.

Maximum life and stability of the lamp are obtained by operating the filament at a high temperature when firing, and at a low temperature thereafter. However, it must not be operated at such a low temperature that sparks or bright incandescent spots form at the filament. Ionization may occur inside the anode (internal firing) rather than in a concentrated path in front of the window. Usually, this occurs when the lamp is turned on while still hot from previous operation. If this occurs, the power supply must be turned off and the lamp allowed to cool before restarting. Similar effects occur with the accessory deuterium lamp, which is handled in the same manner.

Before assuming that the hydrogen lamp is faulty and needs to be replaced, the output from the hydrogen lamp power supply should be checked. If it is determined that the power supply is maintaining a stable filament current and voltage for the lamp anode, and the lamp still does not operate properly, then replace it as follows:

1. Disconnect instrument and power supply power cords.
2. Lift off instrument cover.
3. Loosen three lugs on the terminal strip alongside the hydrogen lamp, noting the color position of the leads for reassembly (red lead is in center).
4. Loosen two clamp screws, turn the lamp window to the open area of the clamps, and lift out the lamp.

NOTE

On some instruments, deuterium lamps must be mounted upside down to clear the base.

5. Insert new lamp and rotate the lamp window until it faces the source mirror. Center the lamp vertically and tighten the clamps. (Do not overtighten).
6. Connect lamp leads to the terminal strip, noting that red lead is in middle.
7. Lamp is now ready to be fired.

7.4 POSITIONING AND FOCUSING HYDROGEN LAMP

When hydrogen (or deuterium) lamps are replaced, major adjustments normally are not necessary. However, alignment of the lamp should be checked to make sure it is delivering maximum energy. It should be noted that alignment of a hydrogen lamp is more critical than alignment of a tungsten lamp.

WARNING

Ultraviolet radiation from a hydrogen (or deuterium) lamp is harmful to the eyes. Protective (not necessarily safety) glasses must be worn during the alignment procedure.

Operators will find it helpful to cover the sample compartment with a folded cloth when undergoing the following alignment procedure: place Operation

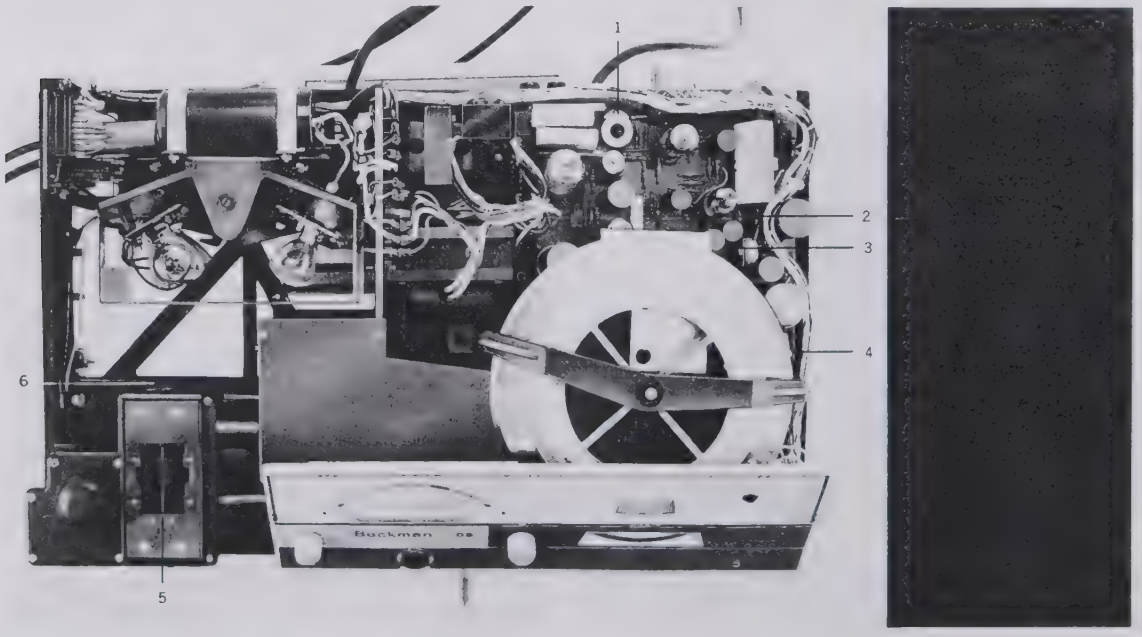


Figure 25. Adjustment Locations

Switch in FLAME position for single-beam operation, turning wavelength dial to 300 mμ, and reduce gain or slit width, if necessary, until the meter reads on scale after each step.

1. Connect the Hydrogen Lamp Power Supply to the spectrophotometer. Turn on its (power supply) power.
2. Turn the Filament Temperature Control of the power supply unit fully clockwise. Allow 5 minutes for filament warmup.
3. Press Start Switch on power supply to start arc in lamp.
4. Adjust hydrogen lamp vertical screw to center light beam vertically on the entrance port just in front of the slit diagonal mirror. A white paper target will facilitate viewing dim image of H_2 lamp. (On the Model DB-G, the filter unit may occlude the beam. Turn the wavelength to about 230 mμ to be sure the filter is out of the way.)
5. Loosen 4-40 lock screw, Figure 24, and adjust hydrogen lamp mirror screw until beam is centered horizontally on the entrance slit aperture.
6. Adjust hydrogen lamp horizontal screw (focus adjust) for maximum energy. Since the focus adjustment is not independent, maintain the beam in its horizontally-centered position.
7. Tighten lock screws.
8. Replace instrument cover.

7.5 ADJUSTING MANUAL SLIT ZERO

The spectrophotometer must be in single-beam operation (FLAME position of Operation Switch on Model DB), slits in MANUAL position, wavelength dial at 500 mμ, tungsten lamp turned on, and gain near maximum. Note the meter displacement with the Manual Slit Adjust in maximum clockwise position (do not jam micrometer against stop). If meter displacement is above 40 divisions, reduce gain.

Set the Manual Slit Adjust on zero, loosen the setscrew at the bottom of the cone-shaped thimble and slide the Manual Slit Adjust in or out until the meter reads 10 divisions higher than it did with the slit in maximum clockwise position. Tighten the setscrew to maintain the meter reading.

Check slit zero as described in Paragraph 7.8.1 and reset micrometer zero if necessary.

7.6 VIBRATING MIRROR AMPLITUDE

The top of the vibrating mirror structure may be seen through the inspection port in the front of the sample compartment if it is illuminated by a flashlight through the beam exit port of the compartment, Figure 25.

Since the vibrating mirror system is moving with simple harmonic motion, it momentarily stops at the extremes of its travel and the gold-plated reeds appear to stand still. The mirrors are moving with the correct amplitude when the reeds appear as one. If two slightly displaced reeds are seen, adjust the amplitude control (R49) until the reeds appear as one.

7.7 PHASING

The phasing control potentiometer (R64) adjusts the switching position of the mercury relay (K1). See Figure 25. It should be noted that the mercury relay does not operate when tilted more than 10° from the vertical. Thus, if the spectrophotometer is set on end for servicing, the relay may stop operating until the instrument is returned to an upright position. The mercury relay must switch during the blank portion of the cycle. There are two methods for determining correct setting:

Method 1 (without oscilloscope):
With the instrument operating normally in double-beam, block the sample beam with the opaque block. Rotate the phasing control potentiometer slowly first in one direction until the meter begins to move off zero; note angular position of the control. Then rotate in the other direction until the meter begins to move off zero. Return the control to a position midway between these two positions. This is the correct setting for the phasing control.

Method 2 (with oscilloscope):
Attach a scope between the junction of R10 and C3 and B− (bottom pin of recorder terminal). Set oscilloscope attenuator for 100 volts and a sweep rate of approximately 18 cycles per second with internal triggering. Two reference pulses will be displayed on the screen.

Switching "spikes" will be seen on both sides of the reference pulses. The phasing control is adjusted properly when the reference pulse is centered between these spikes. See Figure 28 (Ref Pulse After Switching).

7.8 FINDING TRUE SLIT ZERO AND SETTING SLIT PROGRAM

Establishing the slit program requires prior determination of true slit zero. Paragraph 7.8.1 describes the technique for determining the slit zero. Upon completing this procedure, the slit program may be set as described in Paragraph 7.8.2.

7.8.1 DETERMINATION OF TRUE SLIT ZERO

Determine true zero in the following manner.

1. Operation Switch at FLAME (SINGLE-BEAM on Model DB-G); Wavelength Control at 500 mμ; Source Selector at VISIBLE; Slit Program Selector at MANUAL; Dynode Voltage Control (GAIN) set ¼-turn from clockwise end (approximately 1000V).
2. Note %T reading with slits closed. If reading is above 10%, reduce dynode voltage. Open slit to 0.04 mm (4 divisions from micrometer zero). Adjust dynode voltage, wavelength, and, or, 100% Adjust Control for a reading of 20% on the meter. Open slits until meter reads 80% ±0.5%.

   NOTE

   Always adjust slits in the direction of **increasing** aperture. If reading of 80% is passed during adjustment, return slits to lower reading and again approach desired 80% reading from the direction of increasing slit aperture.

3. Note the number of micrometer divisions the slits must be opened from 0.04 mm to achieve desired 80% reading. Subtract this number from 0.04 mm to obtain true slit zero. Unless the micrometer zero is readjusted, make all slit settings with respect to this true slit zero.

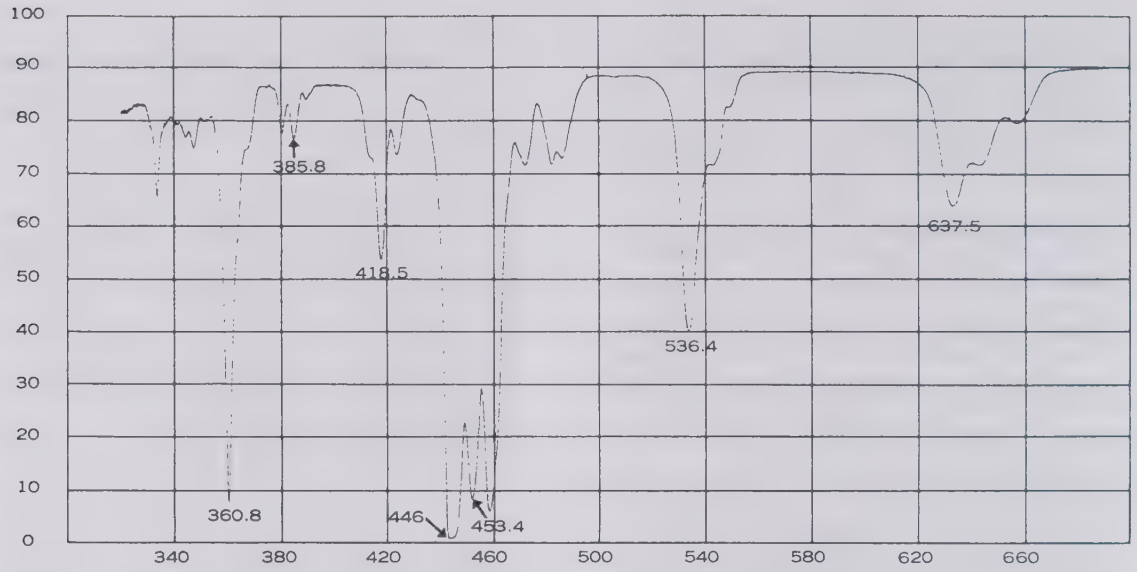


Figure 26. Transmission Spectrum of Holmium Oxide Filter (Tungsten Lamp) with Model DB

EXAMPLE: With slits set at 0.04 mm (4 divisions) and meter reading 20%T, the slits are opened to 0.09 mm (9 divisions) to achieve 80% reading. Difference between 0.09 and 0.04 is 5 divisions; when this is subtracted from 0.04 mm, a true slit zero of —0.01 mm (1 division below zero on micrometer) is obtained.

The above setting uses the principle of energy changing by the square of the change in slit setting. Thus as the slit width is changed 2X the original value, the resultant energy changes 4X the original value.

7.8.2. SETTING SLIT PROGRAM

Set slit program in the following manner:

1. Open slit 0.04 mm from true slit zero on the Model DB (0.07 mm on Model DB-G). Use value of true zero determined in Paragraph 7.8.1.
2. Adjust dynode voltage for on-scale reading of %T, and note reading.
3. Close slits and turn Slit Program Selector to NARROW position on Model DB (to position 1 on Model DB-G).
4. Adjust slit cam follower to obtain the same reading as in Step 2 (±10%T). Turn screw clockwise to increase slit width.

NOTE

Access to slit cam follower is obtained by button plug on lower right front of the spectrophotometer, and inserting screwdriver in the hole. Take care not to angle the screwdriver upward, or the wavelength follower may be adjusted mistakenly.

7.9 WAVELENGTH CALIBRATION

Wavelength calibration can be done with accuracy when the Holmium Oxide Filter Accessory, described in Paragraph 8.10, is used as a wavelength reference.

Use the following wavelength references in conjunction with Figures 26 and 27.

	MODEL DB	MODEL DB-G
279.3 mμ	±0.7 mμ	±0.5 mμ
287.6 mμ	±0.7 mμ	±0.5 mμ
333.8 mμ	±0.7 mμ	±0.5 mμ
360.8 mμ	±1.5 mμ	±0.5 mμ
418.5 mμ	±1.5 mμ	±0.5 mμ
536.4 mμ	±2.0 mμ	±0.5 mμ
637.5 mμ	±4.0 mμ	±0.5 mμ

To check wavelength accuracy, set Operation Switch at NORMAL for double-beam operation, Slit Program Selector at NARROW for Model DB (1 on Model DB-G), select tungsten lamp above 330 mμ and hydrogen lamp below 330 mμ. Set 0 and 100%T with clear beam, then insert holmium oxide filter in the sample beam. Slowly scan manually through each wavelength reference until the absorption dip is found. Always approach each point from long to short wavelength (i.e., approach 360.8 mμ from 365 mμ). Check wavelength in accordance with the chart given in this paragraph.

If the wavelength calibration is off, recalibrate the instrument in the following manner:

1. Remove cover from the instrument and place a cover over the sample compartment.
2. Loosen screws holding wavelength scale on the Wavelength Control.
3. Set Wavelength Control at absorption peak (536.4 mμ band).
4. Rotate wavelength scale (while holding Wavelength Control) until scale reads 536.4 mμ. (If scale cannot be rotated sufficiently to make the adjustment, tighten screws holding wavelength scale and adjust by rotating the collimating mirror horizontal position screw, Figure 60.)

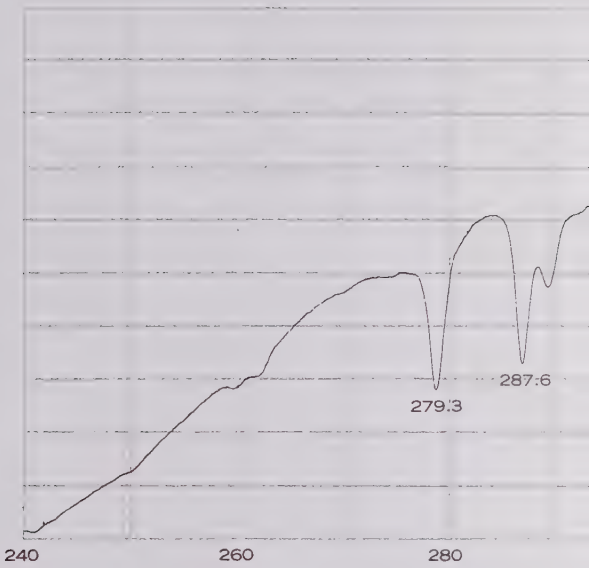


Figure 27. Transmission Spectrum of Holmium Oxide Filter (Hydrogen Lamp

5. Check other wavelength values and readjust 536.4 mμ line as required to bring all lines within the specifications in the chart. Fine adjustment may be accomplished by turning the collimator mirror horizontal position screw. (This is done most easily with an offset screwdriver or hex-nut driver to get increased leverage.) Do not adjust the two collimator mirror vertical position screws as this will de-focus the collimator.)

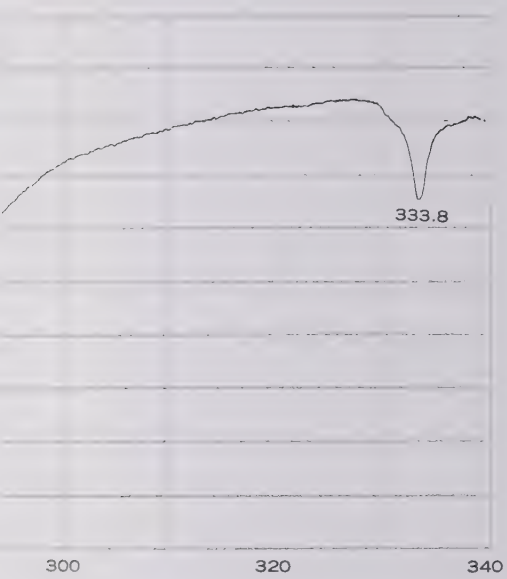
7.10 REFERENCE AMPLIFIER FEEDBACK POTENTIOMETER ADJUSTMENT

The reference amplifier feedback potentiometer R17 is adjusted properly when the instrument leaves the factory and should not require adjustment unless it is accidentally moved. See Figure 25. To display the reference pulse, connect an oscilloscope in the same manner as Method 2 of Phasing, Paragraph 7.7. Rotate the potentiometer in both directions and note appearance of a spike on the top leading edge of the reference pulse. R17 is properly adjusted when this spike is just discernible.

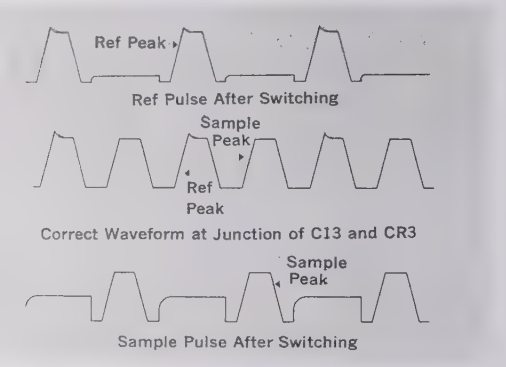
7.11 REPLACING PHOTOMULTIPLIER TUBE

The procedure is the same for a 1P28A or R136 tube:

1. Remove power cord from receptacle.
2. Remove the instrument cover and bottom panel.
3. Remove the rubber cap located at the left of the sample compartment.
4. Support the top of the photomultiplier tube with one hand and push on the centering pin of the octal socket with a pencil or suitable rod.
5. Replace the tube with a new one.
6. Replace rubber cap and bottom panel. Place suitable dark cloth over sample compartment.
7. Operate the spectrophotometer in single-beam mode. Adjust the horizontal detector mirror screws, for maximum output, and lock in position.



) with Model DB



re 28. Oscilloscope Patterns

2 TUBE REPLACEMENT

tubes used in these spectrophotometers are stand- tubes and checks made on a transconductance cker are indicative with the exception of V7 K5). V7 can be tested in operation by checking open loop gain of the amplifier.

3 CLEANING MIRRORS

he dust cannot be blown from the mirrors with nitrogen, proceed as follows:

Mix a rich suds of a suitable detergent, such as Dreft (never use soap).

Soak a ball of fresh surgical cotton in the suds, handle the cotton with tweezers only. Body oils are difficult to remove from mirrors.

Draw the saturated cotton over the mirror. Do not touch the mirror with the tweezers.

Rinse immediately with distilled water.

Rinse immediately with clean ethyl alcohol.

lo not let the mirror start to dry between rinses.

NOTE

Do not remove mirrors for cleaning. Special fixtures are required for alignment. The only mirrors exposed to dust are the source mirror and entrance slit diagonal. These may be cleaned by placing a tissue at the base of the mirror and using fine-tipped squeeze bottles for rinsing. Always remove power cord from socket before cleaning any mirrors.

7.14 SAMPLE COMPARTMENT POSITIONING

The sample compartment supports the sample and reference cells as well as blocking the beam in between the sample and reference pulses. This compartment is positioned properly at the factory and should not be removed unless an oscilloscope is available for positioning. To position the sample compartment, connect an oscilloscope between the junction of C13, CR3 and B− (lower terminal of recorder output, Figure 25.) Set attenuator for 100 volts and sweep rate at approximately 70 cycles per second, internal trigger, folding the reference pulse over the sample pulse. With the spectrophotometer operating normally in double-beam mode, adjust the rear of the sample compartment to superimpose the sample and reference pulses as received on the oscilloscope. Position the front of the sample compartment to center the sample and reference beams on the exit ports.

NOTE

Widen the slits and set the wavelength at approximately 500 mμ. Place a small rectangular card in each of the beams and visually determine the centering. Remove the cards and recheck beam superimposition. See Figure 28 for oscilloscope patterns.

EIGHT ACCESSORIES

By choosing one or a number of the following useful accessories, the capabilities of these spectrophotometers can be greatly extended or refined to a given highly precise area of analysis.

8.1 FOR ATOMIC ABSORPTION MEASUREMENT

Attached to the Model DB or DB-G, as in Figure 29, the Beckman Model 1301 Atomic Absorption System gives the spectroscopist an analytical flame method for direct determination of trace metallic elements by the sensitive and broadening techniques of atomic absorption and flame emission spectroscopy. The complete system offers triple purpose usefulness and is engineered to permit switching to regular and independent spectrophotometry studies with ease.

8.2 FOR STRIP CHART RECORDING

Small and compact, the 93500 and 93506 Laboratory Potentiometric Recorders provide five-inch chart presentation of data. See Figure 32. The 93500 recorder accepts d.c. signals for linear recording in the 0 to 100 mv range; the 93506 recorder accepts either 0 to 100 mv in linear mode, or 100 to 10 mv in log mode.

The Beckman 100500 and 100502 Laboratory Potentiometric Recorders, Figure 30, offer a ten-inch chart presentation in a high performance instrument still capable of being placed on a bench top. The 100500 recorder is designed for linear spans of 0 to 1, 0 to 10 and 0 to 100 mv, while the 100502 recorder provides a one-decade log span for each range.

8.3 FOR EXTENDED WAVELENGTH RANGE

The 28190 Hydrogen Lamp Accessory, extends the wavelength range of the 1400 Model DB below 320 mμ to 205 mμ. The 1401, 1402 Models DB and all Models DB-G are factory-equipped with both the tungsten and hydrogen discharge lamps.

Available lamps include:

BECKMAN PART NO.	DESCRIPTION
2305	Tungsten Lamp, (standard) 32 cp (candlepower), emits radiation between 320 to 3500 mμ.
8333	Hydrogen Discharge Lamp, emits radiation between 185 to 375 mμ.
96280	Deuterium Lamp, for microanalyses and high resolution purposes; emits radiation between 185 to 375 mμ, but has greater intensity than 8333 Hydrogen Discharge Lamp.
2260	Mercury Vapor Lamp, makes wavelength calibration easy and accurate, emits very sharp lines in range from 180 to 1500 mμ.

8.4 FOR REGULATED POWER VOLTAGES

The 71700 Hydrogen Lamp Power Supply, Figure 31, required for use of hydrogen, deuterium or mercury discharge lamps, is a line-operated power supply which provides the necessary regulated voltages for 115-volt, 60-Hz a.c. operation of the sources.

Figure 29. Atomic Absorption System Attached to Model DB

Figure 30. Laboratory Potentiometric (Ten-Inch) Recorder

Figure 31. Hydrogen Lamp Power Supply

Figure 32. Lamp Power Supply, Scale Expander, Five-Inch Recorder with Model DB

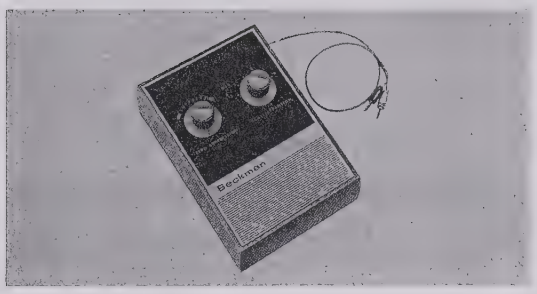


Figure 33. Scale Expander

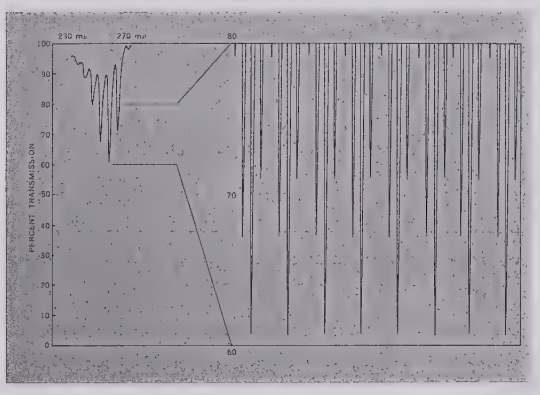


Figure 34. Spectrum of Benzene Showing Use of Scale Expander

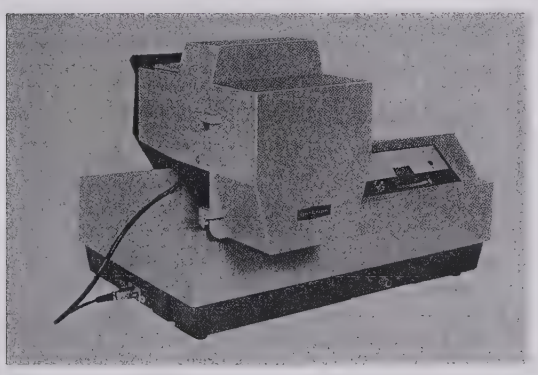


Figure 35. Reflectance Accessory

Figure 36. Sequential Sampler

8.5 FOR DIFFERENT SCANNING SPEEDS

Various wavelength drive speeds provided by these accessories give the spectrophotometers flexibility of operation by permitting a choice of scanning speeds. Available are:

BECKMAN PART NO.		SCANNING SPEED
28180	(Single Speed)	50 mμ/min (for 1400 Model DB)
	(73398—50-Hz)	
74475	(Dual Speed)	5 and 25 mμ/min (Not for Model DB-G)
	(73397—50-Hz)	
72099	(Dual Speed)	10 and 40 mμ/min (for DB) 12.5 and 50 mμ/min (for DB-G)
	(73395—50-Hz)	
73272	(Dual Speed)	20 and 80 mμ/min (for DB) 25 and 100 mμ/min (for DB-G)
	(73396—50-Hz)	

8.6 FOR SCALE EXPANSION

The 73490 Scale Expander, Figures 32 and 33, provides increased sensitivity for critical measurements by expanding to full scale any 50%, 20% or 10% of a linear (transmittance) recording, and permitting one-half decade shifts in log (absorbance mode). Also see Figure 34.

8.7 FOR REFLECTANCE STUDIES

The W136957 Reflectance Accessory converts the Models DB and DB-G to spectroreflectometers, Figure 35. With the unit, which is useful throughout the visible operating range, and well into the ultraviolet (250 mμ or less), complete measurements of color intensity and composition may be made, including transmittance analyses, reflectance determinations and tristimulus measurements of color. Quality control applications extend to use with opaque or transparent materials, color-matching for absolute duplication, and surface reflectivity.

8.8 FOR SEQUENTIAL SAMPLING

The W137199 Sequential Sampler speeds handling of multiple or successive sample by providing an externally-mounted sample chamber and a suction source, Figure 36, to aspirate sample into the sample compartment for measurement.

8.9 RED-SENSITIVE PHOTOMULTIPLIER

For greatly improved sensitivity in the red region above 600 mμ, the 100133 R136 Photomultiplier Tube is recommended as a replacement for the standard 1P28A tube. Figure 15 compares sensitivities of the two tubes. Sensitivity of the R136 is approximately equivalent to the 1P28A photomultiplier at all other wavelengths.

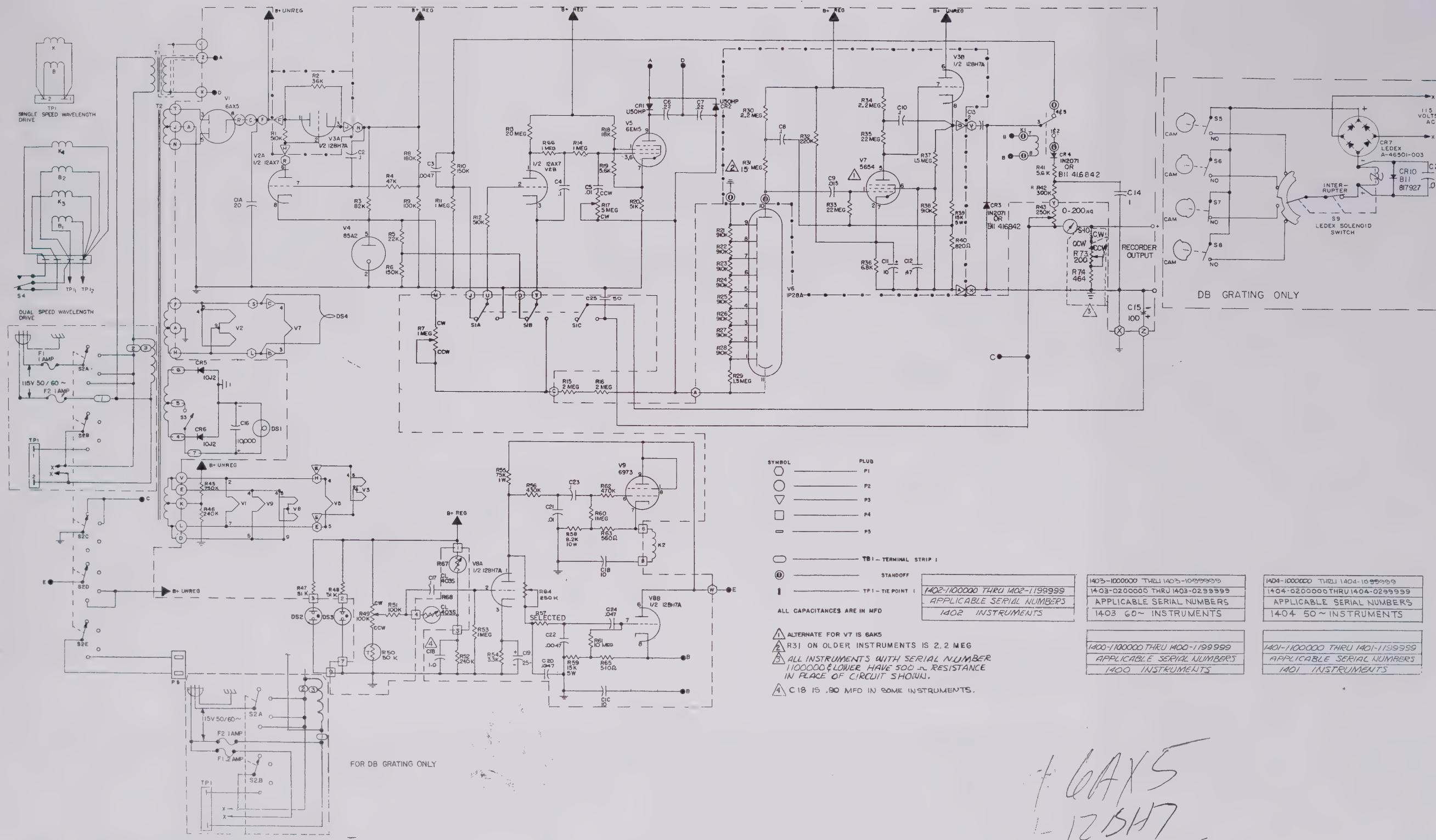
8.10 HOLMIUM OXIDE FILTER

The 96157 Holmium Oxide Filter provides sharp, discrete absorption bands which are useful in calibrating the wavelength accuracy of the Models DB and DB-G, although such determinations with this filter are not as accurate as those gained with use of a mercury lamp. Figures 26 and 27 illustrate spectra obtained with tungsten and hydrogen lamps in the Model DB.

8.11 ABSORPTION CELLS

The following absorption cells are available as replacements and as accessories for the Models DB and DB-G:

Beckman Part No.	Cell Type	Pathlength (mm)	Description	Wavelength (mμ)
75196 (set of 2)	Liquid	1	Silica Rectangular	205-770
75168 (set of 2)	Liquid	5	Silica Rectangular	205-770
75184 (set of 4)	Liquid	10	Silica Rectangular	205-770
75172 (set of 2)	Liquid	10	Silica Rectangular (Glass Stoppered)	205-770
75197 (set of 2)	Liquid	40	Silica Rectangular	205-770
97290	Liquid		Micro-Aperture Flow Cell (requires 70669 Sample Compartment Cover)	220-2500
97460	Liquid		Micro-Aperture Flow Cell (Demountable Sides)	220-2500
97260	Liquid		Microcell (requires 97472 Flow Cell Spacer)	
104186			Variable Beam Attenuator (requires 97260 Liquid Microcell)	
96160			Flow Cell Assembly	



SYMBOL	PLUG
⬡	P1
○	P2
▽	P3
□	P4
–	P5
⬭	TB1 – TERMINAL STRIP 1
Ⓐ	STANDOFF
▮	TP1 – TIE POINT 1

ALL CAPACITANCES ARE IN MFD

△1 ALTERNATE FOR V7 IS 6AK5
△2 R31 ON OLDER INSTRUMENTS IS 2.2 MEG
△3 ALL INSTRUMENTS WITH SERIAL NUMBER 1100000 & LOWER HAVE 500 Ω RESISTANCE IN PLACE OF CIRCUIT SHOWN.
△4 C18 IS .90 MFD IN SOME INSTRUMENTS.

1402-1100000 THRU 1402-1199999
APPLICABLE SERIAL NUMBERS
1402 INSTRUMENTS

1403-1000000 THRU 1403-1099999
1403-0200000 THRU 1403-0299999
APPLICABLE SERIAL NUMBERS
1403 60~ INSTRUMENTS

1404-1000000 THRU 1404-1099999
1404-0200000 THRU 1404-0299999
APPLICABLE SERIAL NUMBERS
1404 50~ INSTRUMENTS

1400-1100000 THRU 1400-1199999
APPLICABLE SERIAL NUMBERS
1400 INSTRUMENTS

1401-1100000 THRU 1401-1199999
APPLICABLE SERIAL NUMBERS
1401 INSTRUMENTS

Figure 37. Schematic Wiring Diagram of Models DB and DB-G

† 6AX5
12BH7
6EM5

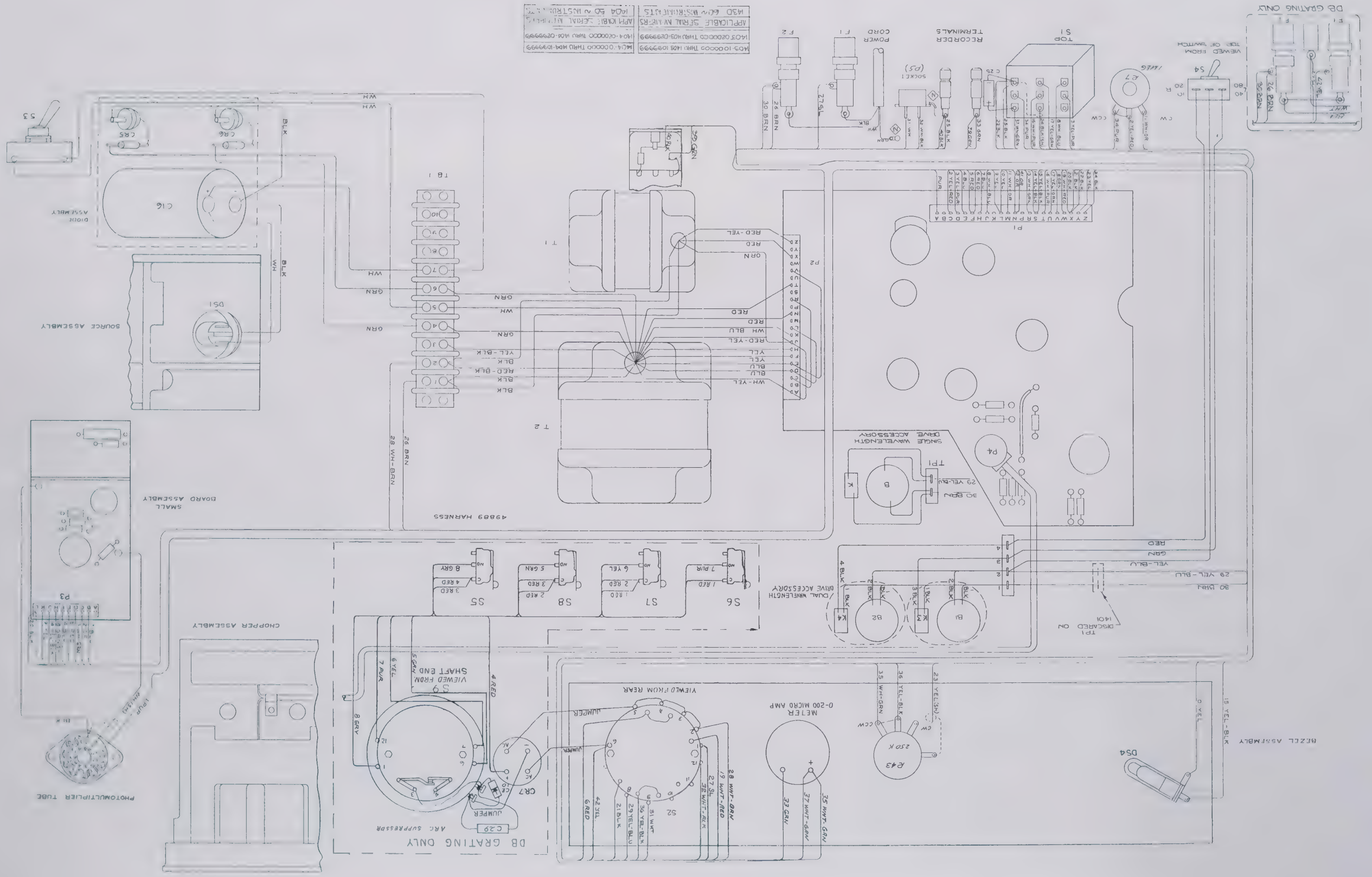


Figure 38. Pictorial Wiring Diagram of Models DB and DB-G

SECTION NINE ILLUSTRATED PARTS LIST

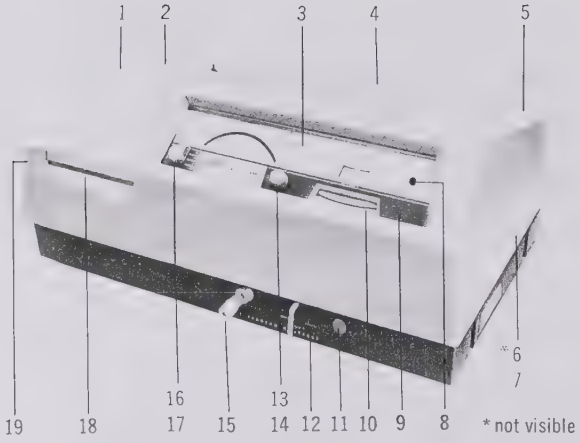
This illustrated parts list provides detailed information about each part included in Beckman Model DB Prism Spectrophotometer and Model DB-G Grating Spectrophotometer. Parts are identified by Beckman number and described by location, dimension, type, function, circuit reference and electrical value as applicable.

There are three versions of the Model DB Prism Spectrophotometer. Basic differences are: 1400 Model DB operates on 50 or 60 Hz and does not include Hydrogen Lamp or Dual-Speed Wavelength Drive; 1401 Model DB operates on 60 Hz and includes Hydrogen Lamp and Dual-Speed Wavelength Drive; 1402 Model DB is the same as 1401 except operates on 50 Hz. There are two versions of the Model DB-G Grating Spectrophotometer: 1403 Model DB-G operates on 60 Hz and 1404 Model DB-G operates on 50 Hz.

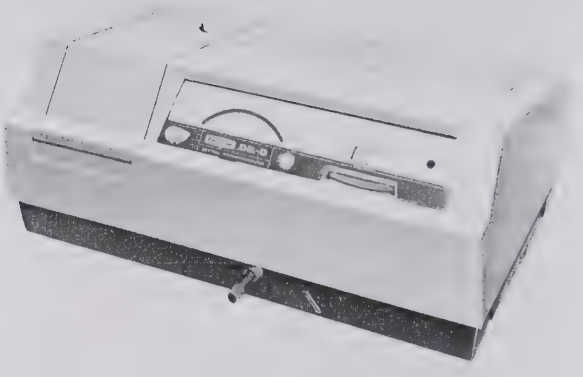
Primary difference between Model DB and Model DB-G is that Model DB includes a prism as part of the optical system and Model DB-G includes a filter and grating. Minor part number differences (for items common to both instruments) are indicated throughout the parts list, however, specific parts exclusive to Model DB-G are shown in Figures 63 through 66, inclusive.

Serial number of the instrument should be specified when ordering replacement parts.

When a component is provided with attaching hardware, the designation "Includes:" follows the component description. Otherwise, if required, the attaching hardware must be ordered separately. The numbers in parentheses after the attaching hardware indicate the quantities required.



Model DB Spectrophotometer



Model DB-G Spectrophotometer

Figure 39. Models DB and DB-G Spectrophotometers

Reference Number	Beckman Part No.	Description	Circuit Reference
1	†49937	Cover, Sample Compartment Gasketed	
		Attaching Parts:	
	49936	Block, Hinge Mounting	
	809896	Screw, Pan Head, 4-40 x ¾ (2)	
	808264	Washer, Split, No. 4 (2)	
	811756	Washer, Flat, No. 4 (2)	
	808591	Nut, Hex, 4-40 (2)	
2	†77322	Cover, Louvered Source Compartment	
		Attaching Parts:	
	94284	Screw, Hex Head, 4-40, special (2)	
	808264	Washer, Split, No. 4 (2)	
	811756	Washer, Flat, No. 4 (2)	
	808591	Nut, Hex, 4-40 (2)	
3	73837	Bezel Assembly, Readout Panel (includes Item 8)	
4	†77323	Cover, Louvered Electronics	
		Attaching Parts:	
	94284	Screw, Hex Head, 4-40, special (2)	
	808264	Washer, Split, No. 4 (2)	
	811756	Washer, Flat, No. 4 (2)	
	808591	Nut, Hex, 4-40 (2)	
5	†77340	Case, Instrument	
6	819379	Stud Assembly	
		Attaching Part:	
	818041	Retainer, Stud	
7	†70668	Sleeve, Cover Retaining (4)	
		Attaching Parts:	
	818040	Receptacle, Sleeve (1 each)	
	808605	Screw, Hex Socket Cap, 10-24 x ½ (1 each)	
	802184	Washer, Split, No. 10 (1 each)	
8	99931	Lamp, Incandescent, Type 51, 6 volts, 0.21 amp (Pilot Light)	DS4
9	49868	Strip, Trim	
		Attaching Part:	
	809890	Screw, Pan Head, 4-40 x ¼ (2)	
10	28088	Wheel, Wavelength, see Figure 58	
11	73915	Plug, Button	
12	49864	Shaft, Slit Program Selector	
13	24747	Potentiometer, 250K ±10%, 2 watts (100% Adjust Control)	R43
		Attaching Parts:	
	816476	Lug, 0.390" dia	
	808295	Washer, Flat, ⅜	
	815649	Nut, Hex, ⅜-32	
14	816809	Knob, Round, no skirt (100% Adjust Control)	
15	49822	Manual Slit Adjustment Assembly, see Figure 41	
		Attaching Part:	
	823766	Setscrew, Hex Socket Cup Point, 8-32 x ⅛	
16	49900	Switch Assembly (Power)	S2
		Attaching Parts:	
	808295	Washer, Flat, ⅜	
	815649	Nut, Hex, ⅜-32	
17	816859	Knob, Pointer, no skirt (Power Switch)	
18	†73223	Gasket, Sample Compartment Internal	
19	†106793	Plug, Button	

†Components of 77324 Case Assembly

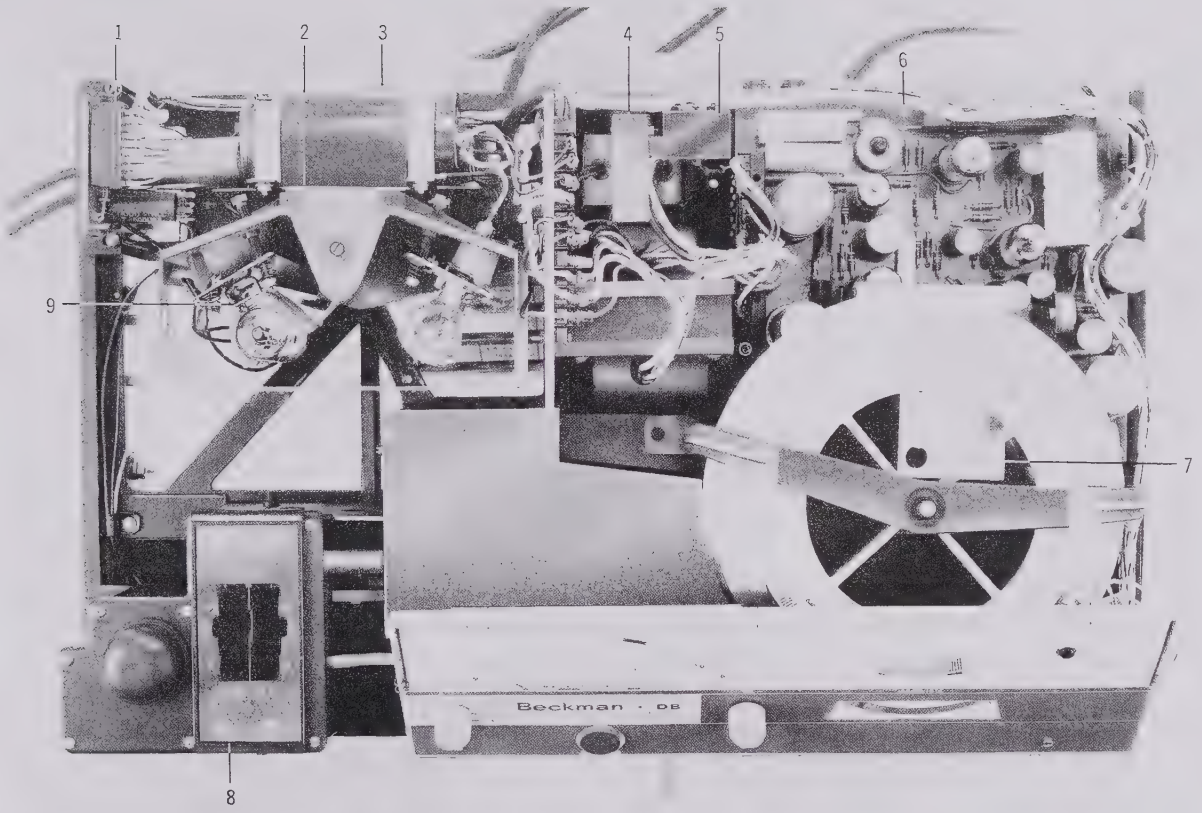


Figure 40. Internal View of Model DB Spectrophotometer Showing Major Assemblies

Reference Number	Beckman Part No.	Description	Circuit Reference
1	49891	Small Component Board Assembly, see Figure 42	
2	28141	Source Assembly, see Figure 43	
		Attaching Parts:	
	809945	Screw, Pan Head, 8-32 x ½ (2)	
	808268	Washer, Split, No. 8 (2)	
3	49873	Diode Assembly, see Figure 45	
		Attaching Part:	
	809916	Screw, Pan Head, 6-32 x ¼ (2)	
4	73222	Transformer Assembly, see Figure 46	
		Attaching Parts:	
	809941	Screw, Pan Head, 8-32 x ¼ (8)	
	808252	Washer, External Tooth, No. 8 (8)	
5	180547	Recorder Span Adjust Assembly, see Figure 47	
		Attaching Part:	
	809890	Screw, Pan Head, 4-40 x ¼	
6	49886	Large Component Board Assembly, see Figures 48 and 49	
		Attaching Parts:	
	49884	Spacer, Mounting (4)	
	49938	Spacer, Component Board (4)	
	809890	Screw, Pan Head, 4-40 x ¼ (8)	
	809894	Screw, Pan Head, 4-40 x ½ (8)	
	811756	Washer, Flat, No. 4 (8)	
	808245	Washer, External Tooth, No. 4 (8)	
7		†Dual-Speed Wavelength Drive Assembly (not illustrated) see Figures 54 and 56.	
8	28128	Sample Compartment Assembly, see Figure 50	
		Attaching Parts:	
	803946	Screw, Hex Socket Cap, 4-40 x ⅜ (4)	
	808264	Washer, Split, No. 4 (4)	
	811756	Washer, Flat, No. 4 (4)	
9	†8333	Hydrogen Discharge Lamp Assembly, see Figure 44	

†Not applicable to 1400 Model DB Spectrophotometers.

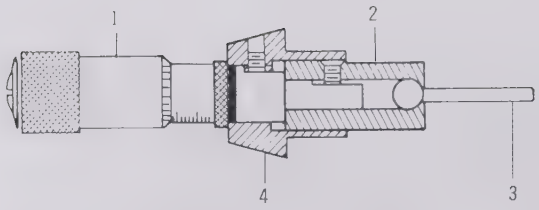


Figure 41. 49822 Manual Slit Adjustment Assembly

Reference Number	Beckman Part No.	Description	Circuit Reference
1	49919	Head, Manual Slit (Micrometer)	
2	49823	Adapter, Ball Joint	
		Attaching Part:	
	824793	Setscrew, Hex Socket Cup Point, 8-32 x ⅛	
3	49824	Joint, Ball	
4	49825	Adapter, Micrometer	
		Attaching Part:	
	824792	Setscrew, Hex Socket Cup Point, 4-40 x ⅛	

Reference Number	Beckman Part No.	Description	Circuit Reference
1	49861	Board, Circuit (without components)	
2	15061	Resistor, 36K ±5%, 2 watts	R2
3	79509	Connector, Male, 10 contacts	
4	9092	Resistor, 51K ±5%, ½ watt	R1
5	23742	Tube, Electron, 12BH7-A	V3
		Attaching Parts:	
	810125	Socket, Tube, 9 pins	
	92234	Shield, Tube	
	79161	Insert, Tube Shield	
6	13193	Resistor, 1.5 meg ±5%, ½ watt	R37
7	12029	Resistor, 2.2 meg ±5%, ½ watt	R34
8	8852	Resistor, 22 meg ±5%, ½ watt	R35
9	24821	Resistor, 15K ±1%, 5 watts	R39
10	810350	Jack, Test	
		Attaching Part:	
	802645	Washer, Fiber	
11	815108	Capacitor, 0.47 μf. 200 volts	C12
12	8147	Resistor, 910K ±5%, ½ watt	R38
13	79172	Resistor, 820K ±5%, ½ watt	R40
14	838201	Capacitor, 10 μf, 25 volts	C11
15	10942	Resistor, 6.8K ±5%, ½ watt	R36
16	815113	Capacitor, 0.1 μf, 400 volts	C10
17	63162	Tube, Electron, 5654	V7
		Attaching Part:	
	99498	Socket, Tube, 7 pins	
18	15083	Resistor, 220K ±5%, ½ watt	R32
19	8852	Resistor, 22 meg ±5%, ½ watt	R33
20	816590	Capacitor, 0.015 μf, 400 volts	C9
21	810349	Jack, Test	
		Attaching Part:	
	802645	Washer, Fiber	
22	20529	Resistor, 15 meg ±5%, ½ watt	R31
23	815113	Capacitor, 0.1 μf, 400 volts	C8
24	12029	Resistor, 2.2 meg ±5%, ½ watt	R30

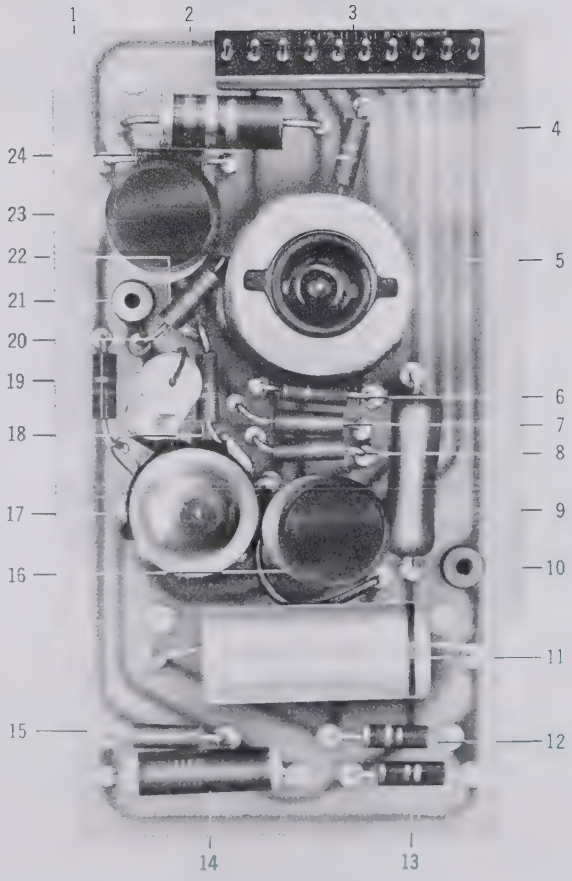
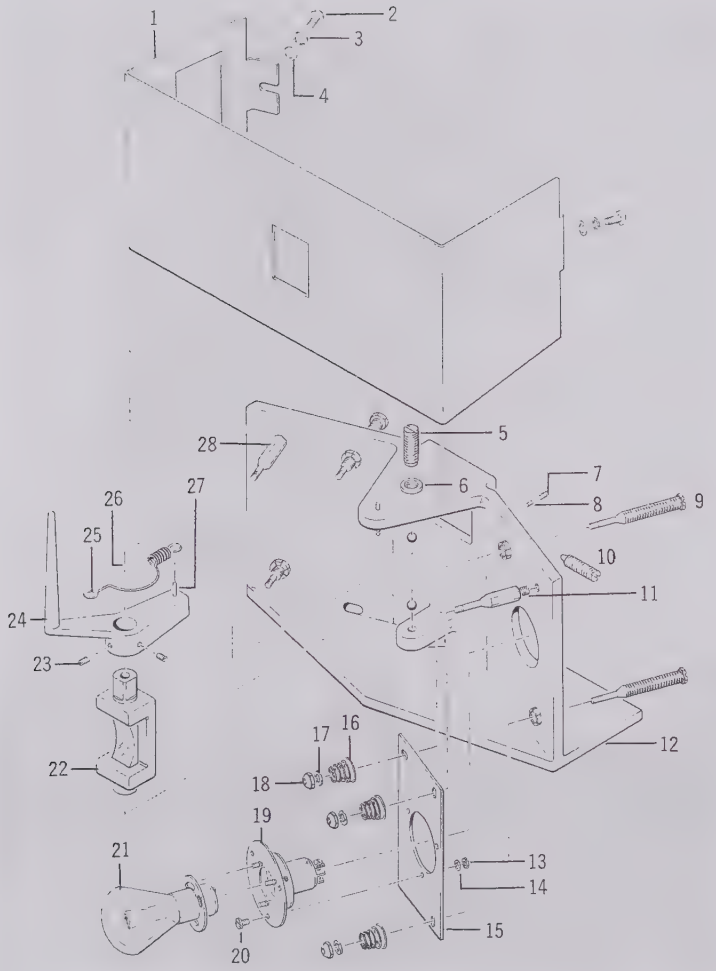


Figure 42. 49891 Small Component Board Assembly



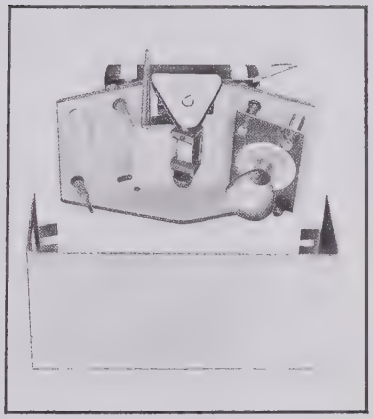


Figure 43. Exploded View of 28141 Source Assembly

Reference Number	Beckman Part No.	Description	Circuit Reference
1	74336	Baffle, Source	
2	810690	Washer, Flat, No. 6 (2)	
3	808266	Washer, Split, No. 6 (2)	
4	804391	Screw, Pan Head, 6-32 x 3/8 (2)	
5	17717	Screw, Adjustment	
6	†824541	Locknut, 1/4-40 (5)	
7	29834	Setscrew, Hex Socket Cup Point, 4-40 x 1/8 (2)	
8	8256	Plug, Nylon (2)	
9	17656	Screw, Hex Socket Adjustment (4)	
10	824184	Setscrew, Hex Socket Oval Point, 10-32 x 3/4 (2)	
11	17657	Spacer, Mounting	
12	28095	Backplate, Source	
13	808591	Nut, Hex, 4-40 (3)	
14	808264	Washer, Spring, No. 4 (3)	
15	28089	Plate, Tungsten Lamp Mounting	
16	12123	Spring, Mounting (3)	
17	811756	Washer, Flat, No. 4 (3)	
18	12124	Nut, Self-locking, 4-40 (3)	
19	22746	Socket, Tungsten Lamp	
20	809891	Screw, Pan Head, 4-40 x 5/16 (3)	
21	2305	Lamp, Tungsten, Type 2331, 6 volts, 4.5 amp	DS1
22	28090	Source Mirror Assembly	
23	823766	Setscrew, Hex Socket Cup Point, 8-32 x 1/8 (2)	
24	28134	Arm, Adjustment	
25	17631	Spring, Mirror Adjustment	
26	40692	Ball, Stainless Steel, 3/16" dia (2)	
27	†12231	Pin, Groove, 0.0938" x 0.375" (2)	
28	49909	Spacer, Mounting	

†Components pressed in place.

Reference Number	Beckman Part No.	Description	Circuit Reference
1	49911	Mounting Plate, Hydrogen Lamp	
		Attaching Parts:	
	12123	Spring, Mounting (3)	
	811756	Washer, Flat, No. 4 (3)	
	12124	Nut, Self-locking 4-40 (3)	
2	809898	Screw, Pan Head, 4-40 x 1 (2)	
3	8333	Lamp, Hydrogen Discharge	
4	29880	Terminal Strip, Riveted	

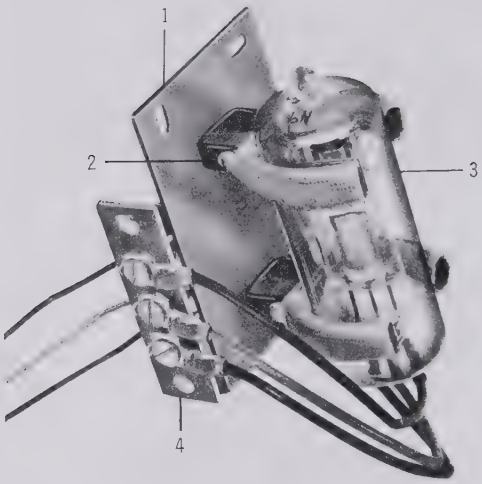


Figure 44. Hydrogen Lamp with 49911 Mounting Plate

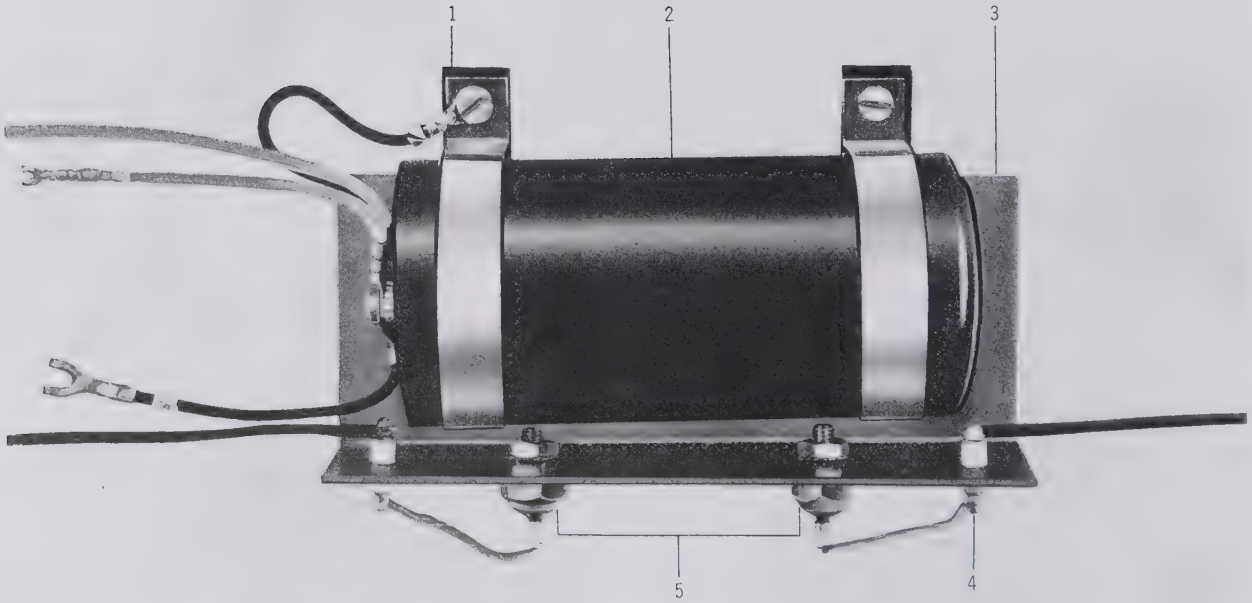


Figure 45. 49873 Diode Assembly

Reference Number	Beckman Part No.	Description	Circuit Reference
1	49832	Strap, Capacitor Mounting	
		Attaching Parts:	
	809917	Screw, Pan Head, 6-32 x 5/16	
	808249	Washer, External Tooth, No. 6	
	808596	Nut, Hex, 6-32	
2	79484	Capacitor, 10,000 μf, 10 volts	C16
3	49894	Bracket, Diode Mounting	
4	28106	Terminal, Insulated	
5	79483	Diode, 10J2	CR5,CR6
		Attaching Parts:	
	808255	Washer, External Tooth, No. 10	
	808588	Nut, Hex, 10-32	

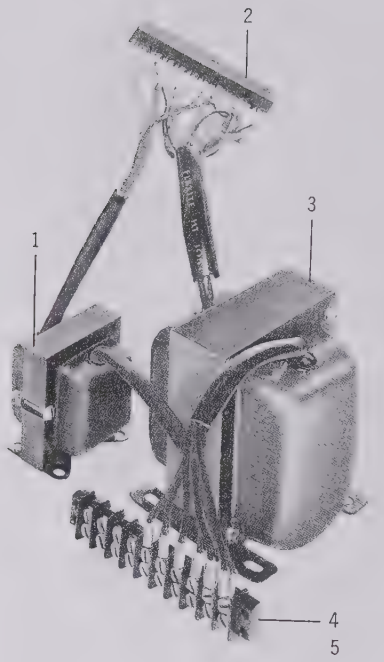


Figure 46. 73222 Transformer Assembly

Reference Number	Beckman Part No.	Description	Circuit Reference
1	28040	Transformer, Photomultiplier	T1
		Attaching Parts:	
	809941	Screw, Pan Head, 8-32 x ¼ (4)	
	808252	Washer, External Tooth, No. 8 (4)	
2	79520	Connector, Printed Circuit, 22 contacts (female)	
3	49874	Transformer, Power	T2
		Attaching Parts:	
	809941	Screw, Pan Head, 8-32 x ¼ (4)	
	808252	Washer, External Tooth, No. 8 (4)	
4	12991	Block, Terminal, 10 terminals	TB1
		Attaching Part:	
	99800	Lug, Terminal	
5	†79510	Marker, Terminal Strip	
		Attaching Parts:	
	809895	Screw, Pan Head, 4-40 x ⅝ (2)	
	808264	Washer, Split, No. 4 (2)	
	808591	Nut, Hex, 4-40 (2)	

†Not a component of 73222 Transformer Assembly

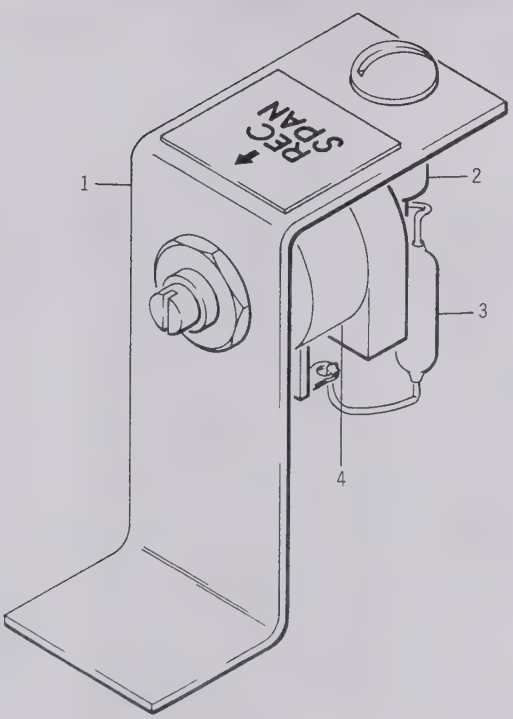


Figure 47. 180547 Recorder Span Adjust Assembly

Reference Number	Beckman Part No.	Description	Circuit Reference
1	180546	Bracket, Mounting	
2	91635	Terminal, Standoff	
		Attaching Part:	
	816060	Screw, Pan Head, 6-32 x 3/16	
	802169	Washer, Internal Tooth, No. 6	
3	811254	Resistor, 464 ohms ±1%, ½ watt	R74
4	839799	Potentiometer, 200 ohms ±20%, 3/10 watt with Switch, SPST	R73,S10

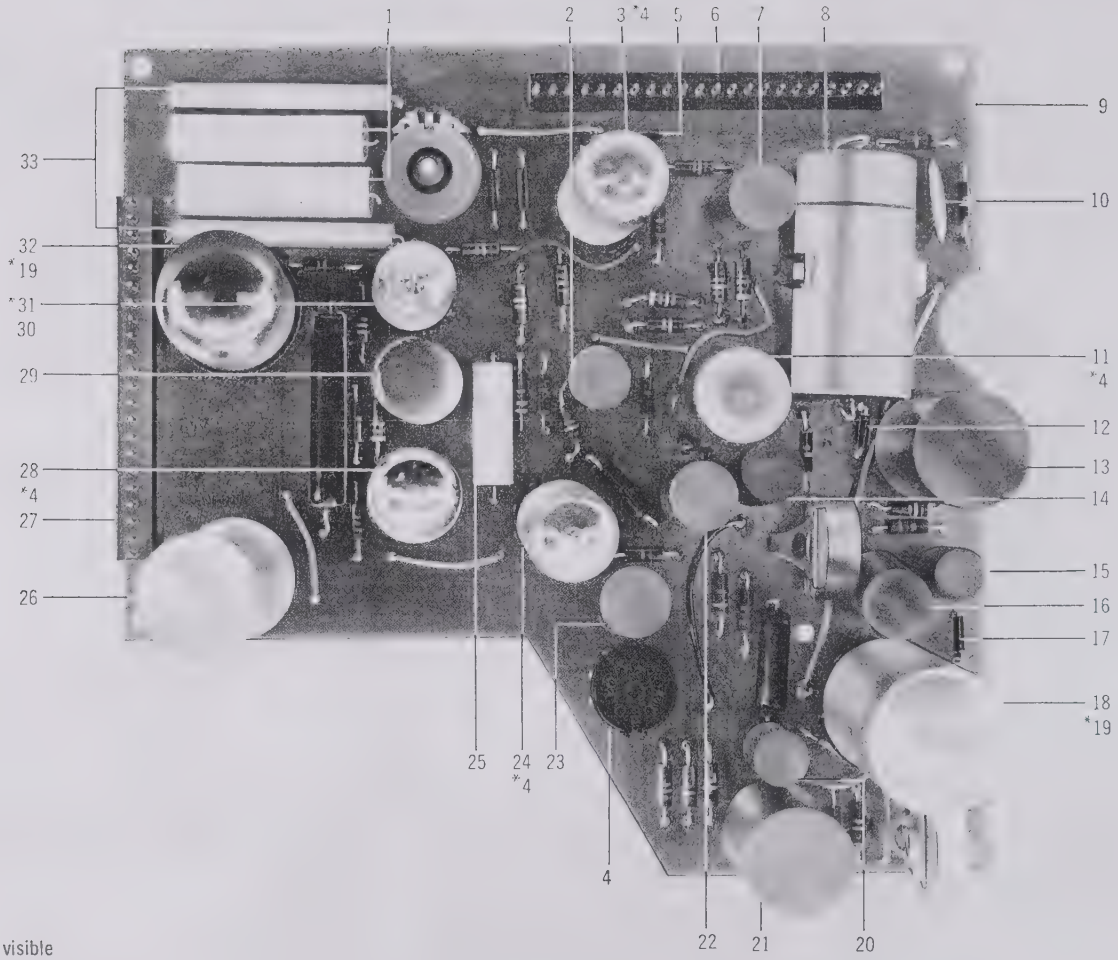


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Figure 48. Miscellaneous Parts of 49886 Large Component Board Assembly

Reference Number	Beckman Part No.	Description	Circuit Reference
1	79497	Capacitor, 0.22 μf, 1000 volts	C7,C6
2	815111	Capacitor, 0.01 μf, 600 volts	C21
3	79513	Tube, Electron, 6EM5	V5
4	99497	Socket, Tube, 9 pins	
5	79500	Capacitor, 0.01 μf, 1600 volts	C5
6	79508	Connector, Printed Circuit, 22 contacts (male)	
7	815113	Capacitor, 0.1 μf, 400 volts	C2
8	815107	Capacitor, 2 μf, 400 volts	C13
9	49887	Board, Riveted Circuit	
10	79501	Capacitor, 0.0047 μf, 100 volts	C3
11	15093	Tube, Electron, 12AX7	V2
12	416842	Diode	CR3
13	815115	Capacitor, 1 μf, 400 volts	C14
14	815114	Capacitor, 0.1 μf, 600 volts	C4
15	79570	Capacitor, 100 μf, 12 volts	C15
16	815055	Capacitor, 0.047 μf, 400 volts	C20
17	416842	Diode	CR4
18	79516	Relay, Chopper	K1

Reference Number	Beckman Part No.	Description	Circuit Reference
19	79512	Socket, Tube, 8 pins	
20	815110	Capacitor, 0.0047 μf, 600 volts	C22
21	815115	Capacitor, 1 μf, 400 volts	C18
22	815113	Capacitor, 0.1 μf, 400 volts	C17
23	815055	Capacitor, 0.047 μf, 400 volts	C24
24	23742	Tube, Electron, 12BH7-A	V8
25	817202	Capacitor, 25 μf, 25 volts	C19
26	79514	Capacitor, 20-10-10 μf, 450 volts	C1A,C1B, C1C
27	79508	Connector, Printed Circuit, 22 contacts (male)	
28	99617	Tube, Electron, 6973	V9
29	815114	Capacitor, 0.1 μf, 600 volts	C23
30	20820	Tube, Electron, 85A2	V4
31	99498	Socket, Tube, 9 pins	
32	24327	Tube, Electron, 6AX5	V1
33	79502	Rectifier, Half-wave, U50HP	CR1,CR2

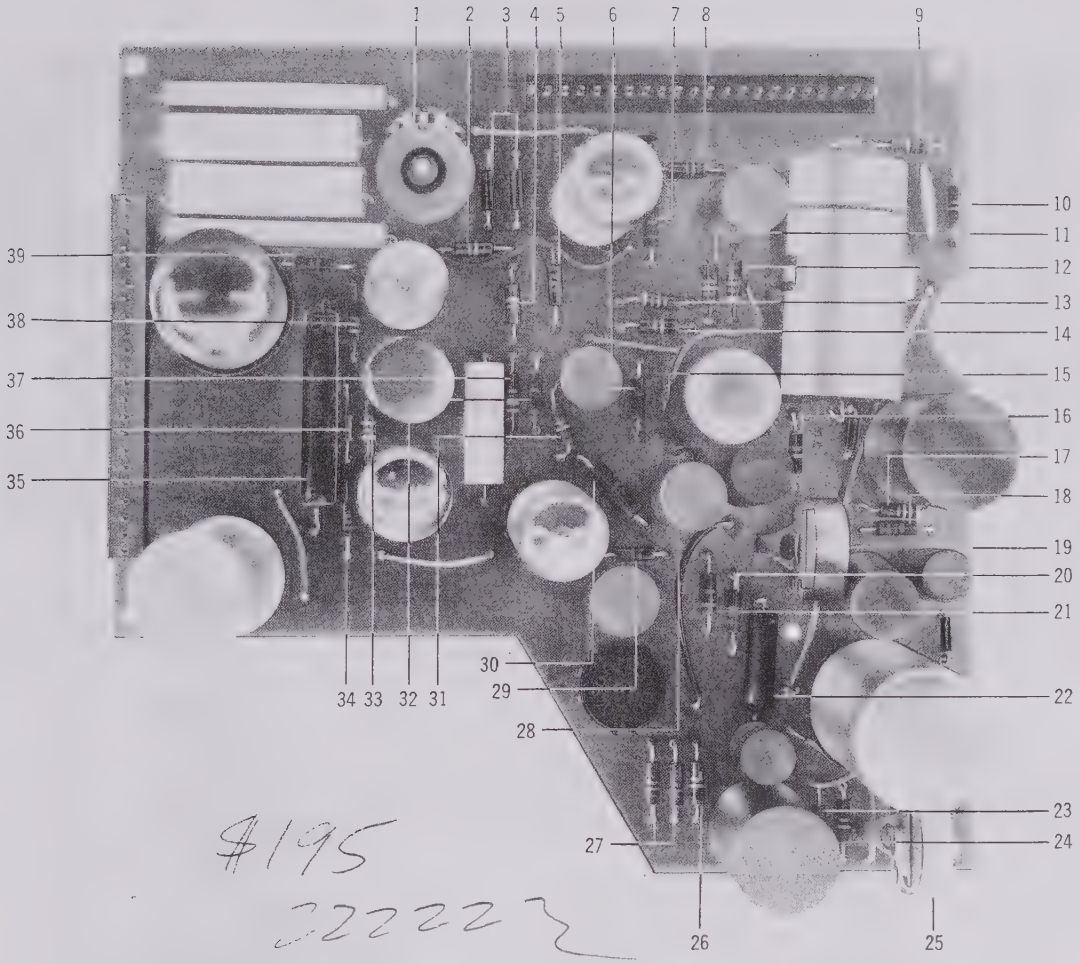

Figure 49. Resistors for 49886 Large Component Board Assembly

Reference Number	Beckman Part No.	Description	Circuit Reference
1	79506	Potentiometer, 5 meg ±20%, ¼ watt	R17
2	565	Resistor, 22K ±5%, ½ watt	R5
3	2209	Resistor, 2 meg ±5%, ½ watt	R16,R15
4	15079	Resistor, 150K ±5%, ½ watt	R6
5	15067	Resistor, 51K ±5%, ½ watt	R20
6	41151	Resistor, 1 meg ±5%, ½ watt	R14
7	15050	Resistor, 5.6K ±5%, ½ watt	R19
8	15056	Resistor, 18K ±5%, ½ watt	R18
9	41151	Resistor, 1 meg ±5%, ½ watt	R11
10	15079	Resistor, 150K ±5%, ½ watt	R10
11	15081	Resistor, 180K ±5%, ½ watt	R8
12	15064	Resistor, 47K ±5%, ½ watt	R4
13	15072	Resistor, 82K ±5%, ½ watt	R3
14	15074	Resistor, 100K ±5%, ½ watt	R9
15	2208	Resistor, 20 meg ±5%, ½ watt	R13
16	9092	Resistor, 510K ±5%, ½ watt	R12
17	8773	Resistor, 300K ±5%, ½ watt	R42
18	15050	Resistor, 5.6K ±5%, ½ watt	R41
19	79426	Potentiometer, 250K ±20%, ¼ watt	R64
20	6543	Resistor, 510 ohms ±5%, ½ watt	R65
21	1554	Resistor, 680K ±5%, ½ watt	R57
22	22765	Resistor, 15K ±3%, 5 watts	R59
23	41150	Resistor, 240K ±5%, ½ watt	R52
24	810837	Thermistor, 50K ±10%, @ 25°C	R50
25	99487	Potentiometer, 100K ±20% ⅓ watt	R49
26	15074	Resistor, 100K ±5%, ½ watt	R51
27	15067	Resistor, 51K ±5%, ½ watt	R48,R47
28	41151	Resistor, 1 meg ±5%, ½ watt	R66
29	8154	Resistor, 10 meg ±5%, ½ watt	R61
30	1388	Resistor, 75K ±5%, 1 watt	R55
31	20356	Resistor, 430K ±5%, ½ watt	R56
32	41151	Resistor, 1 meg ±5%, ½ watt	R53
33	15086	Resistor, 470K ±5%, ½ watt	R62
34	79492	Resistor, 560 ohms ±5%, ½ watt	R63
35	79504	Resistor, 8.2K ±3%, 10 watts	R58
36	41151	Resistor, 1 meg ±5%, ½ watt	R60
37	15460	Resistor, 3.3K ±5%, ½ watt	R54
38	41150	Resistor, 240K ±5%, ½ watt	R46
39	15088	Resistor, 750K ±5%, ½ watt	R45

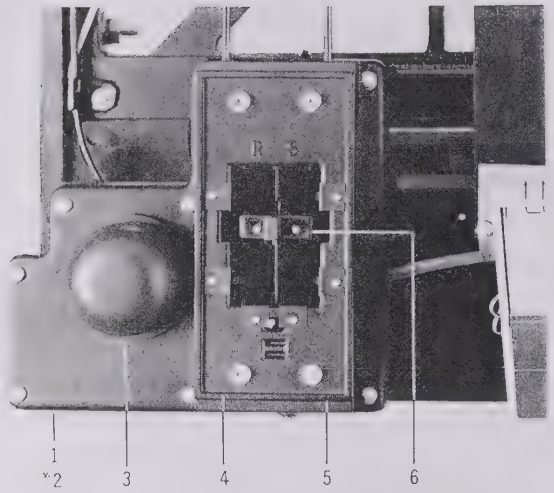

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Figure 50. Sample and Detector Compartments

Reference Number	Beckman Part No.	Description	Circuit Reference
1	129105	Cover, Detector Compartment	
		Attaching Part:	
	809890	Screw, Pan Head, 4-40 x ¼ (5)	
2	49849	Gasket, Detector Compartment Cover (cemented in place)	
3	49828	Cover, Phototube	
4	28128	Sample Compartment Assembly	
		Includes:	
	28062	Spring, Cell Holder (4)	
		Attaching Part:	
	816287	Screw, Drive, 0-3/16 (1 each)	
	28061	Spring, Cell Holder (2)	
		Attaching Part:	
	816287	Screw, Drive, 0-3/16 (1 each)	
5	49827	Gasket, Sample Compartment	
6	28129	Cell Holder Assembly	
		Includes:	
	28193	Holder, Cell	
	28061	Spring, Cell Holder (2)	
		Attaching Part:	
	816287	Screw, Drive, 0 3/16	

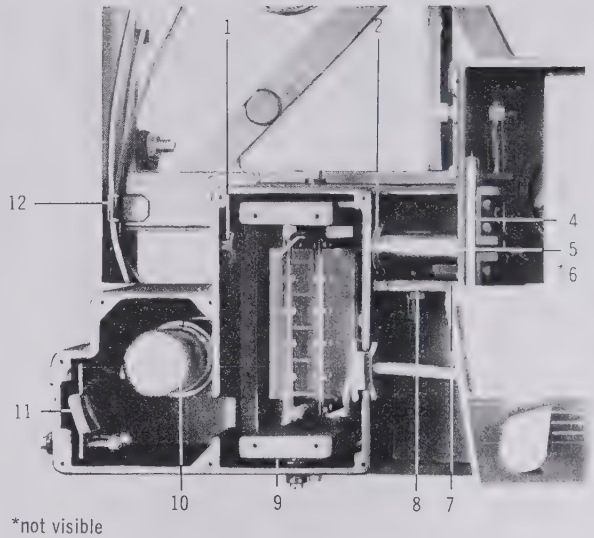

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Figure 51. Internal View of Sample and Detector Compartment

Reference Number	Beckman Part No.	Description	Circuit Reference
1	49854	Plug, Button (3)	
2	49811	Gasket, Lens Holder	
3	49871	Eccentric, Slit Adjust	
		Attaching Part:	
	817009	Nut, Jam, ¼-40	
4	49820	Aperture, Lens (2)	
		Attaching Part:	
	2395	Clamp, Retaining, 0.59" dia	
5	49821	Holder, Lens	
6	28215	Lens, Exit	
		Attaching Parts:	
	99328	Ring, Retaining, External, 0.594"	
	2395	Clamp, Retaining, 0.59" dia	
7	28132	Diagonal Mirror Assembly	
		Attaching Parts:	
	28049	Plate, Diagonal Mirror	
	803949	Screw, Hex Socket Cap, 4-40 x ½	
8		Screw, Adjustment (special)	
	79003	for Model DB, ¼-40 x 1	
	22710	for Model DB-G, ¼-40 x ⅝	
9	49885	Chopper Assembly, see Figure 52	
		Attaching Parts:	
	824863	Setscrew, Hex Socket Oval Point, ¼-28 x ¾ (3)	
	819218	Nut, Jam, ¼-28 (3)	
10	853035	Phototube, 1P28A	V6
11	49807	Receiver Mirror Assembly	
		Attaching Parts:	
	49857	Spring, Mirror Adjustment (3)	
	49851	Screw, Mirror Adjustment (3)	
	816616	Washer, Flat, No. 6 (3)	
	802137	Washer, Flat, No. 8 (1 only)	
12	3343	Clamp, Cable, 3/16"	
		Attaching Parts:	
	809890	Screw, Pan Head, 4-40 x ¼	
	808264	Washer, Split, No. 4	
	811756	Washer, Flat, No. 4	

Reference Number	Beckman Part No.	Description	Circuit Reference
1	49865	Mirror, Chopper	
2	79491	Terminal, Insulated	
3	49842	Coil Assembly	K2
		Attaching Parts:	
	809890	Screw, Pan Head, 4-40 x ¼ (3)	
	808264	Washer, Split, No. 4 (3)	
	810715	Washer, Flat, No. 4 (3)	
4	49881	Cable, Chopper	
		Attaching Parts:	
	3344	Clamp, Cable, ⅛"	
	49826	Grommet, Chopper Cable	
	809889	Screw, Pan Head, 4-40 x 3/16	
	808264	Washer, Split, No. 4	
	810715	Washer, Flat, No. 4	
5	49835	Bar, Armature (2)	
		Attaching Parts:	
	828772	Screw, Pan Head, 0-80 x 3/16 (1 each)	
	802158	Washer, Split, No. 0 (1 each)	
	816428	Washer, Flat, No. 0 (1 each)	
	802214	Nut, Hex, 0-80 (1 each)	
6	49833	Vane, Upper	
		Attaching Parts:	
	816386	Screw, Pan Head, 0-80 x ¼	
	802158	Washer, Split, No. 0	
	816428	Washer, Flat, No. 0	
7	49880	Photocell Assembly, CL-403S	R67
8	49837	Photocell Holder Assembly	
		Attaching Part:	
	801706	Nut, Potentiometer, ⅜-32	
9	49882	Plug, Photocell	
10	49879	Lamp Assembly	DS2,DS3
11	49880	Photocell Assembly, CL-403S	R68
12	49834	Vane, Lower	
		Attaching Parts:	
	816386	Screw, Pan Head, 0-80 x ¼	
	802158	Washer, Split, No. 0	
	816428	Washer, Flat, No. 0	
13	28055	Riveted Chopper Assembly	
		Attaching Parts:	
	803949	Screw, Hex Socket Cap, 4-40 x ½ (6)	
	808264	Washer, Split, No. 4 (6)	

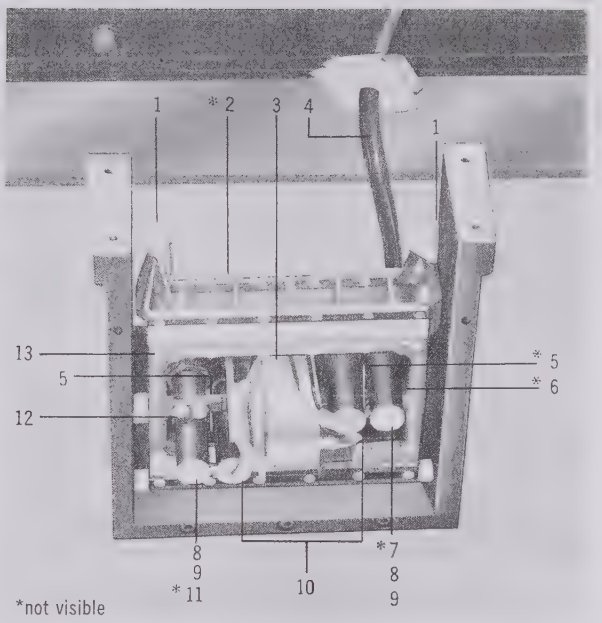


Figure 52. 49885 Chopper Assembly

Reference Number	Beckman Part No.	Description	Circuit Reference
1	76121	Gasket, Light Shield	
2	76120	Shield, Chopper Light	
3	809889	Screw, Pan Head, 4-40 x 3/16 (2)	
		Attaching Parts:	
	808264	Washer, Split, No. 4 (2)	
	810715	Washer, Flat, No. 4 (2)	
4	49875	Cradle, Chopper	

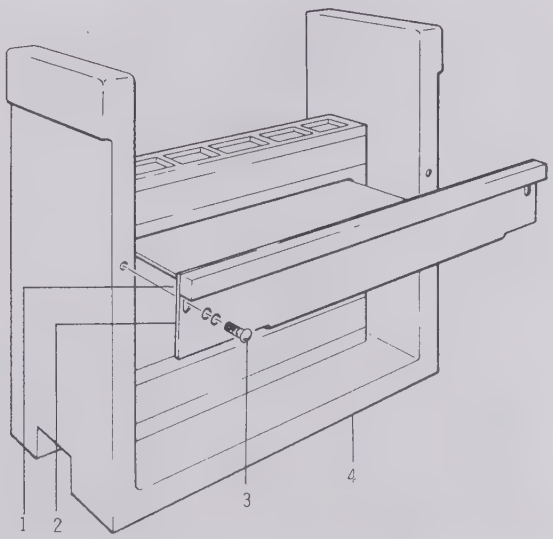


Figure 53. Chopper Light Shield

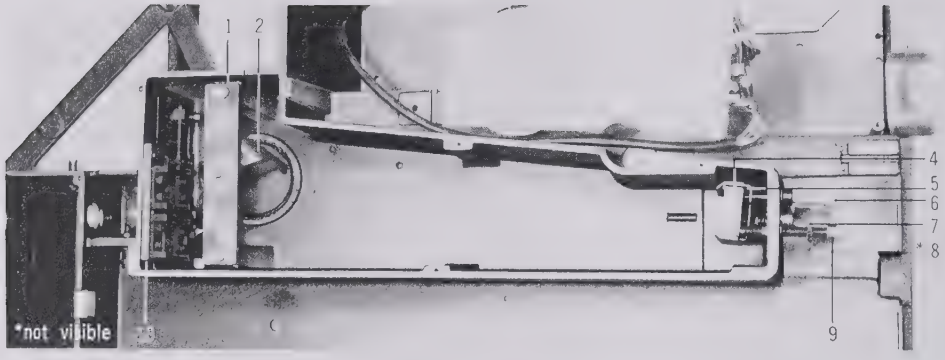


Figure 54. Dual-Speed Wavelength Drive Assembly and Internal View of Monochromator

Reference Number	Beckman Part No.	Description	Circuit Reference
1	‡75084	Prism Mount Assembly	
		Includes:	
	28122	Strap, Prism Mount	
	17717	Screw, Adjustment	
	824541	Nut, Self-locking, ¼-40	
		Attaching Parts:	
	803996	Screw, Hex Socket Cap, 8-32 x ¼ (2)	
	808268	Washer, Split, No. 8 (2)	
2	‡28026	Prism Assembly	
		Attaching Parts:	
	40692	Ball, Stainless Steel, 3/16" dia	
	823675	Screw, Hex Socket Cap, 6-32 x ⅜	
3		‡‡Dual-Speed Wavelength Drive Assembly, see Figure 56	
4	28021	Mirror, Collimator	
5	28065	Holder, Mirror	
6		Screw, Compensating	
	74315	for Model DB	
	132132	for Model DB-G	
7	28060	Spacer, Collimator Mirror	
8	28057	Spring, Collimator Mirror	
		Attaching Part:	
	42268	Pin, Mirror Spring	
9	11082	Screw, Adjustment, ¼-40 x 1¾ (2)	
10		Slit Jaw Assembly, see Figure 55	
	75020	for Model DB	
	105175	for Model DB-G	
		Attaching Parts:	
	816368	Screw, Hex Socket Cap, 4-40 x 5/16 (2)	
	808264	Washer, Split, No. 4 (2)	

‡Not applicable to Model DB-G Spectrophotometers.

‡‡The only version of the Model DB that is not supplied with the Dual-Speed Wavelength Drive is the 1400 Spectrophotometer. Refer to Section 8 of this instruction manual for accessories used with Models DB and DB-G Spectrophotometers.

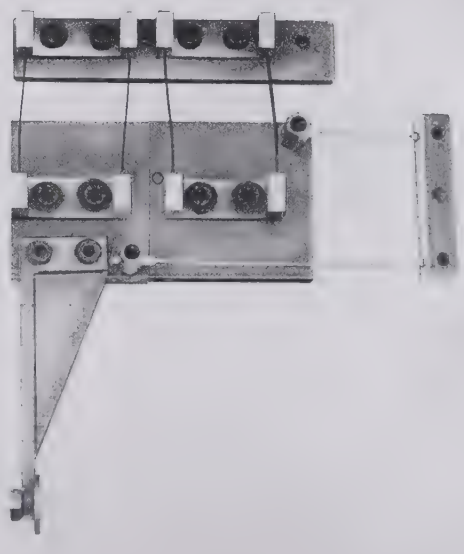


Figure 55. Slit Jaw Assemblies. Individual components for the 75020 (Model DB) and 105175 (Model DB-G) Slit Jaw Assemblies cannot be replaced separately because of the close tolerances required.

Figure 56. Dual-Speed Wavelength Drive Assembly
73254 — 1401 Model DB, 60-Hz
73466 — 1402 Model DB, 50-Hz
105169 — 1403 Model DB-G, 60-Hz
105170 — 1404 Model DB-G, 50-Hz

Reference Number	Beckman Part No.	Description	Circuit Reference
1	8802	Strip, Terminal, 6 lugs	
		Attaching Parts:	
	809890	Screw, Pan Head, 4-40 x ¼ (2)	
	808245	Washer, External Tooth, No. 4 (2)	
2	73257	Gear, 64T	
		Attaching Part:	
	803470	Setscrew, Hex Socket Cup Point, 4-40 x ⅛ (2)	
3	73256	Gear, 32T	
		Attaching Part:	
	803470	Setscrew, Hex Socket Cup Point, 4-40 x ⅛ (2)	
4	499	Clamp, Cable, ¼"	
		Attaching Parts:	
	804391	Screw, Pan Head, 6-32 x ⅜	
	808266	Washer, Split, No. 6	
	808596	Nut, Hex, 6-32	
5	73252	Cable and Switch Assembly	S4
6		Motor, Timer, with Relay, ½ rpm, 30 torque in-oz, 115 volts	B2,K4
	28179	for 1401 Model DB and 1403 Model DB-G (60-Hz)	
	811724	for 1402 Model DB and 1404 Model DB-G (50-Hz)	
7	125993	Support, Dual-Speed Wavelength Drive	
		Attaching Parts:	
	816092	Screw, Pan Head, 8-32 x 3 (2)	
	808252	Washer, External Tooth, No. 8 (2)	
	802248	Nut, Hex, 8-32 (2)	
8		Motor, Timer, with Relay, 30 in-oz, 115 volts	B1,K3
	810354	for 1401 Model DB. 1/16 rpm (60-Hz)	
	811725	for 1402 Model DB. 1/16 rpm (50-Hz)	
	838406	for 1403 Model DB-G. 1/20 rpm (60-Hz)	
	838407	for 1404 Model DB-G. 1/20 rpm (50-Hz)	
9	73256	Plate, Motor Mounting	
		Attaching Parts:	
	804391	Screw, Pan Head, 6-32 x ⅜ (4)	
	808266	Washer, Split, No. 6 (4)	
	808596	Nut, Hex, 6-32 (4)	

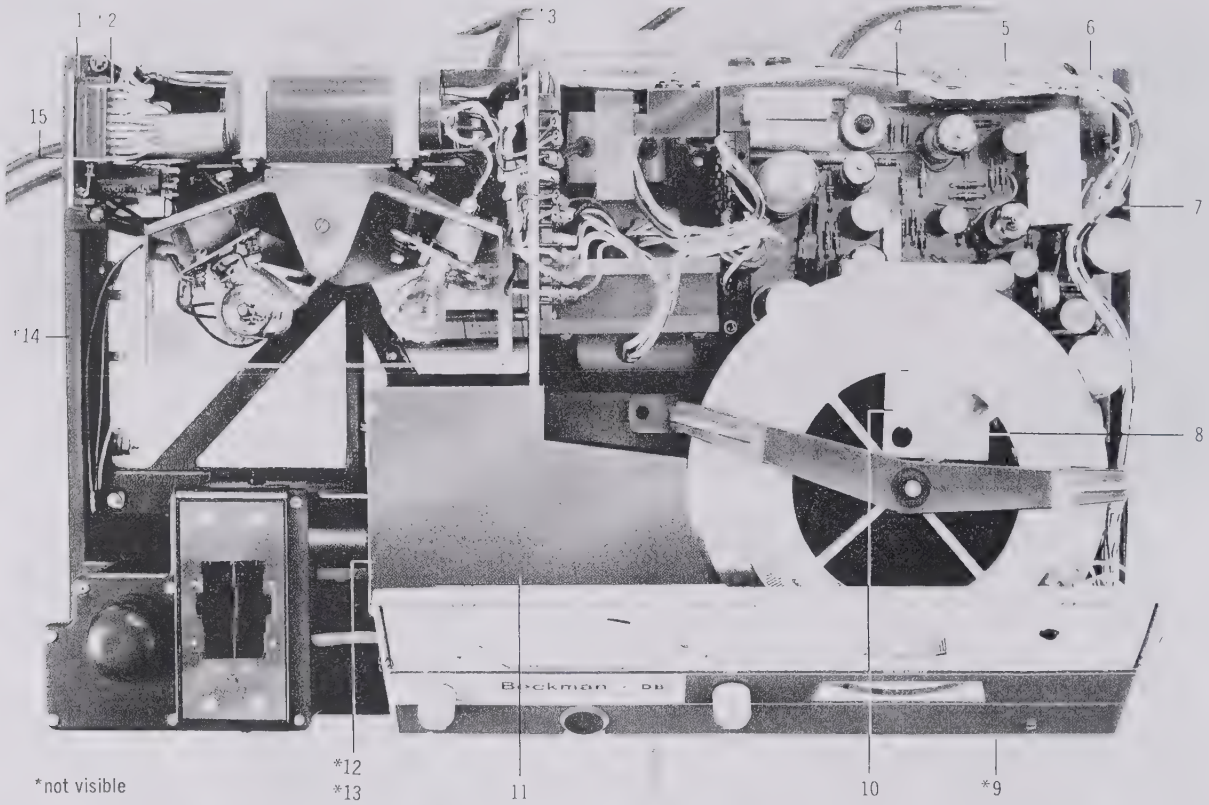


Figure 57. Internal View of Model DB Spectrophotometer

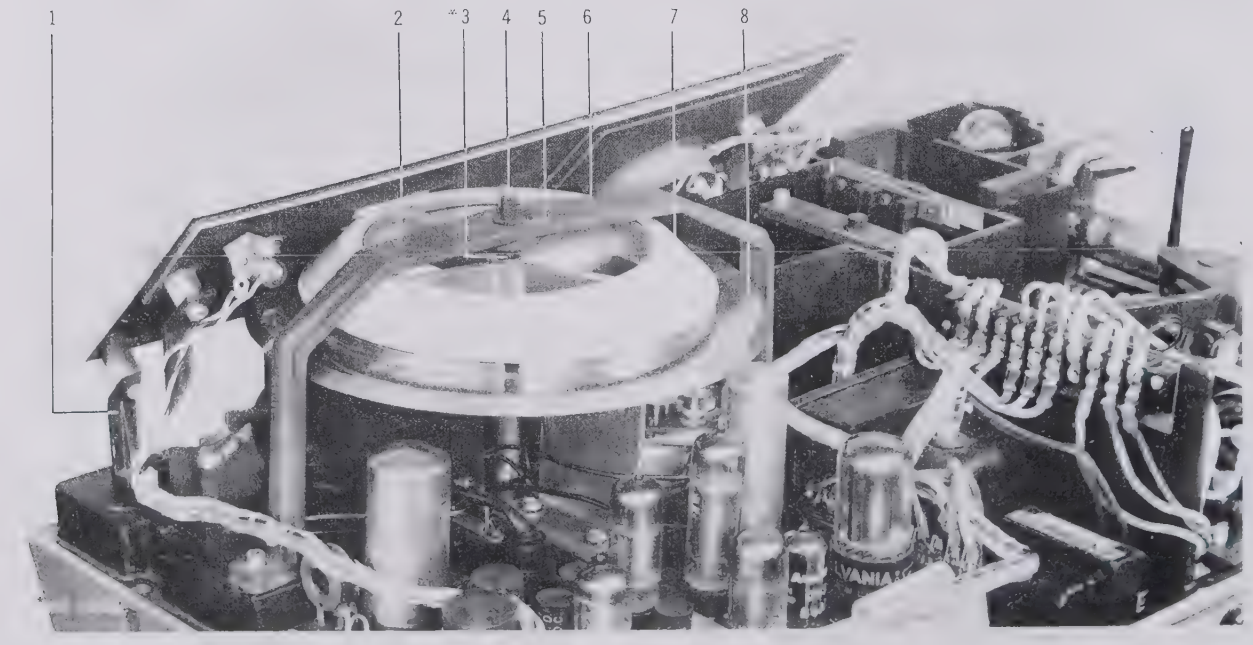


Figure 58. Wavelength Wheel and Related Components

Reference Number	Beckman Part No.	Description	Circuit Reference
1	73287	Bracket, Small Component Board Mounting	
		Attaching Parts:	
	819554	Screw, Nylon, Pan Head, 6-32 x ½	
	816090	Screw, Pan Head, 8-32 x 2½	
	816092	Screw, Pan Head, 8-32 x 3	
2	73892	Insulator, Component Board	
3	3344	Clamp, Cable, ⅛"	
		Attaching Parts:	
	809894	Screw, Pan Head, 4-40 x ½	
	808264	Washer, Split, No. 4	
	811756	Washer, Flat, No. 4	
	808591	Nut, Hex, 4-40	
4	79520	Connector, Printed Circuit, 22 contacts (female)	
5	49852	Cover, Bottom (Electronics)	
		Attaching Parts:	
	809953	Screw, Pan Head, 8-32 x ¼ (4)	
	808269	Washer, Split, No. 8 (4)	
	816618	Washer, Flat, No. 8 (4)	
6	49889	Harness Assembly (includes Items 4 and 15)	
7		Base, Spectrophotometer	
	49918	for Model DB	
	105136	for Model DB-G	
8	†74414	Baffle, Wavelength	
		Attaching Parts:	
	809941	Screw, Pan Head, 8-32 x ¼ (3)	

Reference Number	Beckman Part No.	Description	Circuit Reference
	808268	Washer, Split, No. 8 (3)	
	802137	Washer, Flat, No. 8 (3)	
9	28124	Cover, Bottom (Sample Compartment and Monochromator)	
		Attaching Parts:	
	809954	Screw, Pan Head, 8-32 x ⅜ (6)	
	808269	Washer, Split, No. 8 (6)	
	816618	Washer, Flat, No. 8 (6)	
10	†54163	Strip, Terminal, 2 lugs	
		Attaching Parts:	
	809890	Screw, Pan Head, 4-40 x ¼ (2)	
	808245	Washer, External Tooth, No. 4 (2)	
11	28107	Cover, Monochromator	
		Attaching Parts:	
	809890	Screw, Pan Head, 4-40 x ¼ (3)	
	803938	Screw, Hex Socket Cap, 4-40 x ¼ (2)	
12	28114	Gasket, Monochromator Cover	
13	46916	Insulator, Monochromator	
14	95971	Cover, Bottom (Source Assembly)	
		Attaching Parts:	
	809953	Screw, Pan Head, 8-32 x ¼ (3)	
	808269	Washer, Split, No. 8 (3)	
	816618	Washer, Flat, No. 8 (3)	
15	79521	Connector, Printed Circuit, 10 contacts (female)	

†Components of 1400 Model DB Spectrophotometer only.

Reference Number	Beckman Part No.	Description	Circuit Reference
1	28098	Bracket, Bezel (2)	
		Attaching Parts:	
	809948	Screw, Pan Head, 8-32 x ⅞ (1 each)	
	808268	Washer, Split, No. 8 (1 each)	
2	75054	Cradle Assembly (includes Items 4, 5 and 6)	
		Attaching Part:	
	812136	Screw, Flat Head, 8-32 x ⅝ (2)	
3	40692	Ball, Stainless Steel, 3/16" dia	
4	17717	Screw, Adjustment	
5	824541	Nut, Self-locking, ¼-40	
6	28044	Cradle, Wavelength Cam	
7		Scale, Wavelength	
	28121	for Model DB	
	105120	for Model DB-G	
		Attaching Part:	
	809889	Screw, Pan Head, 4-40 x 3/16	
8	28088	Wheel, Wavelength	
		Attaching Part:	
	823766	Setscrew, Hex Socket Cup Point, 8-32 x ⅛	

Reference Number	Beckman Part No.	Description	Circuit Reference
1	810305	Capacitor, 50 μf, 6 volts	C25
2	28164	Foot, Rubber	
		Attaching Parts:	
	809946	Screw, Pan Head, 8-32 x 5/8	
	808268	Washer, Split, No. 8	
	802248	Nut, Hex, 8-32	
3	809975	Screw, Shoulder, 10-32 x 3/8	
4	97412	Door, Flame	
5	28210	Lock, Door	
		Attaching Parts:	
	811448	Screw, Pan Head, 10-32 x 3/4	
	808588	Nut, Hex, 10-32	
6	49801	Phototube Socket Assembly, see Figure 60	
7	70667	Slit Arm Assembly	
		Includes:	
	49845	Arm, Slit	
	28120	Bracket, Slit Arm	
		Attaching Parts:	
	803996	Screw, Hex Socket Cap, 8-32 x 1/2 (2)	
	808268	Washer, Slit, No. 8 (2)	
	72562	Spring, Slit Arm	
		Attaching Parts:	
	816049	Screw, Pan Head, 4-40 x 1 1/4	
	811756	Washer, Flat, No. 4	
	808591	Nut, Hex, 4-40	
	49845	Screw, Adjustment (2)	
		Attaching Parts:	
	2397	Nut, Lock, 1/4-40 (1 only)	
	40692	Ball, Stainless Steel, 3/16" dia (1 only)	
8	28151	Spring, Extension	
9	49846	Hook, Spring	
10	49831	Collar, Ball Joint	
		Attaching Parts:	
	49824	Joint, Ball	
	29834	Setscrew, Hex Socket Cup Point, 4-40 x 1/8 (2)	

Reference Number	Beckman Part No.	Description	Circuit Reference
11	73243	Lift, Wavelength Arm	
12	811834	Pin, Groove, 0.0469" dia x 0.500" long	
13	28159	Spring, Compression	
		Attaching Part:	
	29834	Setscrew, Hex Socket Cup Point, 8-32 x 1/8	
14	75055	Wavelength Arm Assembly	
		Includes:	
	28023	Arm, Wavelength	
	16042	Pin, Groove, 0.0938" dia x 0.500" long	
	49845	Screw, Adjustment	
		Attaching Parts:	
	97621	Plug, Plastic	
	823882	Setscrew, Hex Socket Cup Point, 8-32 x 1/4	
15	49819	Collar, Wavelength Arm Lift	
		Attaching Part:	
	29834	Setscrew, Hex Socket Cup Point, 8-32 x 1/8	
16	133655	Cam Shaft Strap Assembly	
		Includes:	
	133654	Strap, Cam Shaft	
	40692	Ball, Stainless Steel, 3/16" dia	
	17717	Screw, Adjustment	
	824541	Nut, Self-locking, 1/4-40	
		Attaching Parts:	
	803996	Screw, Hex Socket Cap, 8-32 x 1/2	
	808268	Washer, Split, No. 8	
17	96288	Cam, Slit	
		Attaching Part:	
	823766	Setscrew, Hex Socket Cup Point, 8-32 x 1/8	

Reference Number	Beckman Part No.	Description	Circuit Reference
1	8147	Resistor, 910K ±5%, 1/2 watt	R21 through R28, inclusive
2	17731	Socket, Tube, 11 pins	
3	13193	Resistor, 1.5 meg ±5%, 1/2 watt	R29

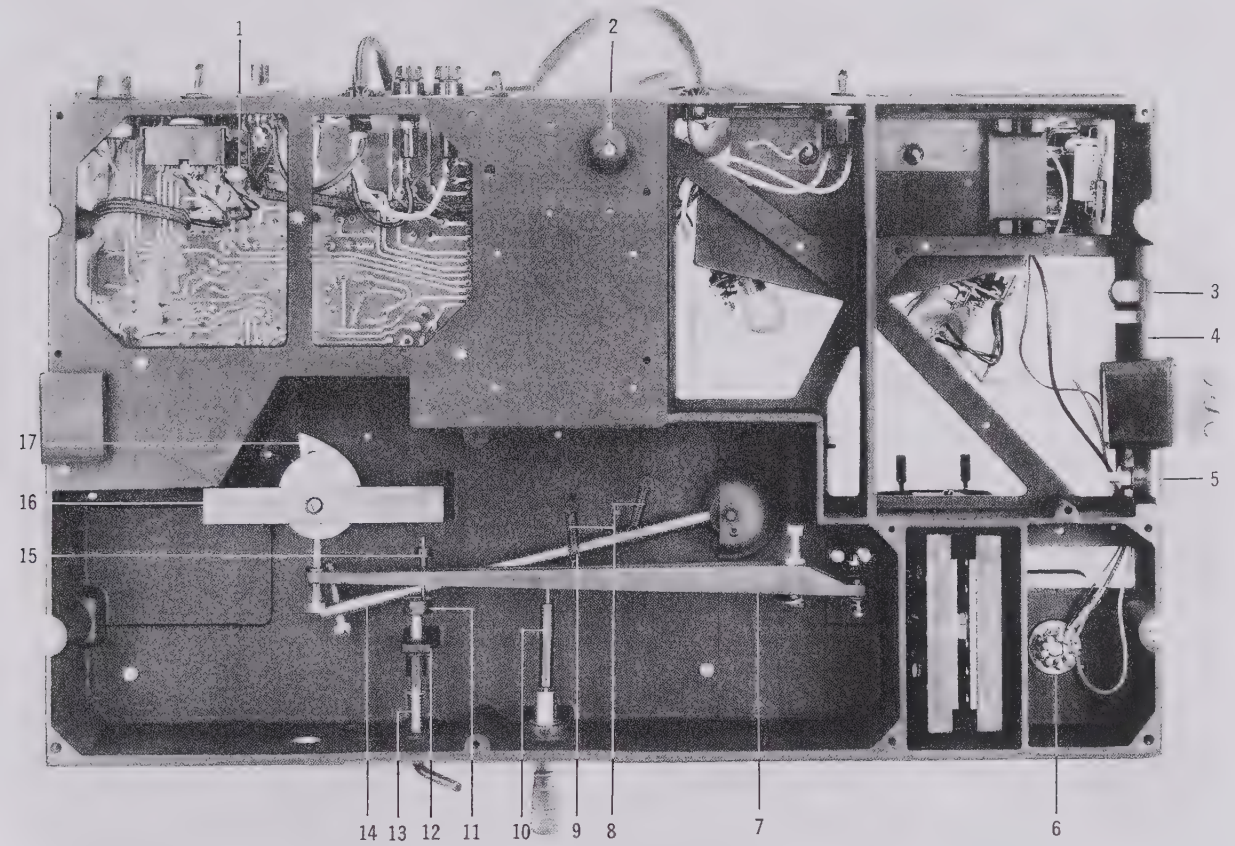


Figure 59. Bottom View of Model DB Spectrophotometer

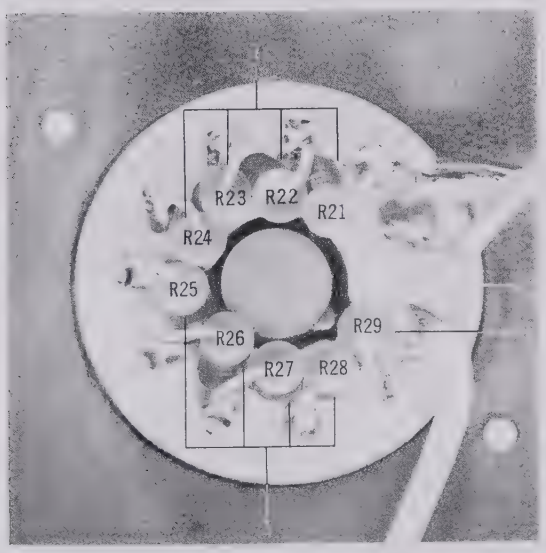


Figure 60. Bottom View of 49801 Phototube Socket Assembly

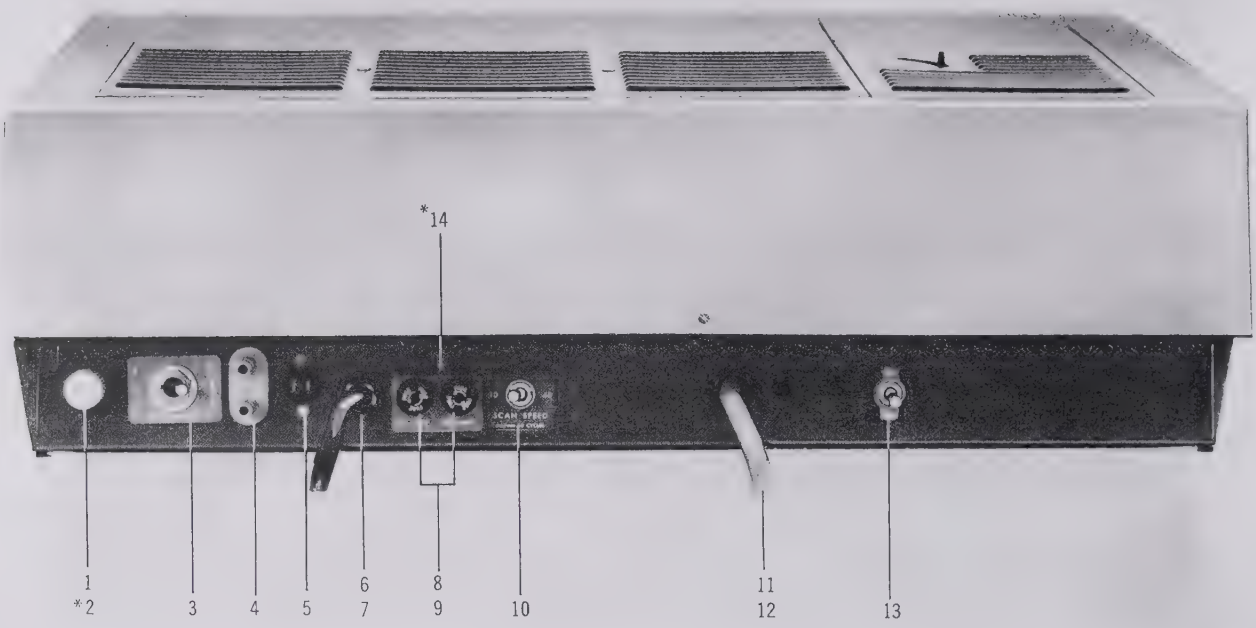


Figure 61. Rear View of Models DB and DB-G Spectrophotometers

Reference Number	Beckman Part No.	Description	Circuit Reference
1	816809	Knob, Dynode Voltage Control	
2	79517	Potentiometer, 1 meg ±20%, 2 watts (Dynode Voltage Control)	R7
3	54045	Switch, Toggle, 3PDT, 10 amp, 250 volts (Flame Operation)	S1
		Attaching Part:	
	810353	Washer, Flat, ½	
4	79621	Binding Post Terminal Assembly	
		Attaching Parts:	
	79396	Washer, Fiber (1 only)	
	808252	Washer, External Tooth, No. 8 (2)	
5	7538	Connector, Rectangle, 2 contacts (male)	
		Attaching Parts:	
	809891	Screw, Pan Head, 4-40 x 5/16 (2)	
	808264	Washer, Split, No. 4 (2)	
	808591	Nut, Hex, 4-40 (2)	
6	75205	Cord, Power, 6′	
7	12042	Clamp, Strain Relief Cable	
8		Fuse, Electrical, 250 volts	
	148	Model DB, 1 amp	F1,F2
	801545	Model DB-G, 0.2 amp	F1
	148	Model DB-G, 1 amp	F2
9	7268	Fuseholder	
10	†73252	Cable and Switch Assembly	
		Includes:	
	806039	Switch, Toggle, SPDT, 1 amp, 250 volts	S4
11	†2236	Cable, Hydrogen Lamp	
12	†12042	Clamp, Strain Relief Cable	
13	73486	Tungsten Lamp Switch Assembly	S3
		Attaching Part:	
	40751	Plate, Switch	
14	††91635	Terminal, Insulator	
		Attaching Parts:	
	804391	Screw, Pan Head, 6-32 x ⅜	
	808266	Washer, Split, No. 6	
	810690	Washer, Flat, No. 6	

†Not included on 1400 Model DB Spectrophotometer
††Applicable to Model DB-G only

Figure 62. Supplies for 1400 Model DB Spectrophotometers

Beckman Part No.	Description	Quantity Furnished
148	Fuse, Electrical, 1.0 amp, 250 volts	5
893	Resistor, 56 ohms ±5%, ½ watt	1
6543	Resistor, 510 ohms ±5%, ½ watt	1
72571	Block, Opaque	1
75172	Cell, Silica Absorption, 10 mm pathlength	set of 2
16988	Plug, Adapter	1
817304	Wrench, Hex, 7/64"	1
817305	Wrench, Hex, 9/64"	1
1894	Wrench Set, Hex	1
134166	Cover, Dust	1
816104	Screw, Pan Head, ¼-20 x ⅜	2
79185	Washer, Flat, ¼	2

NOTE: For Supplies furnished with 1401 and 1402 Model DB Spectrophotometers, see Figure 67

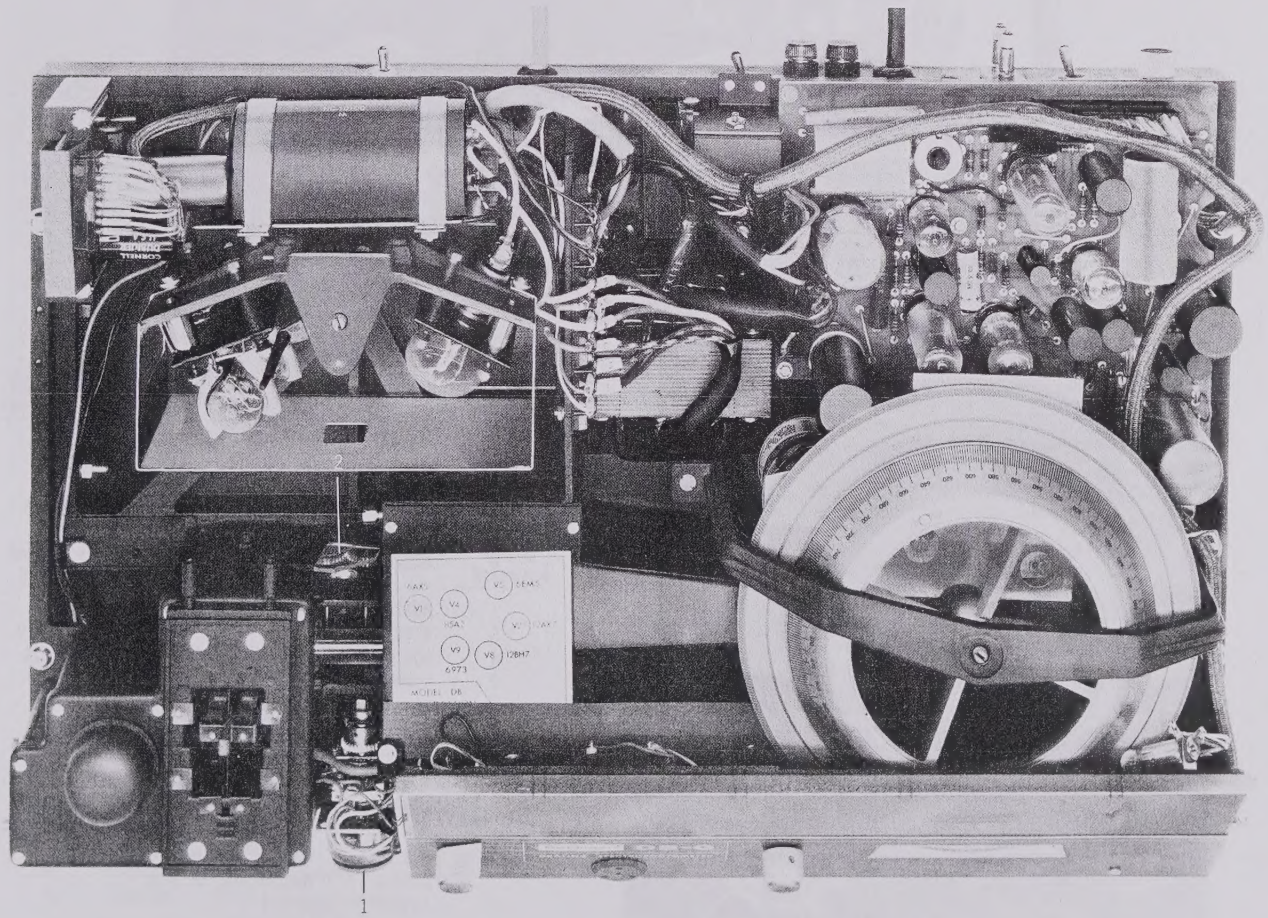
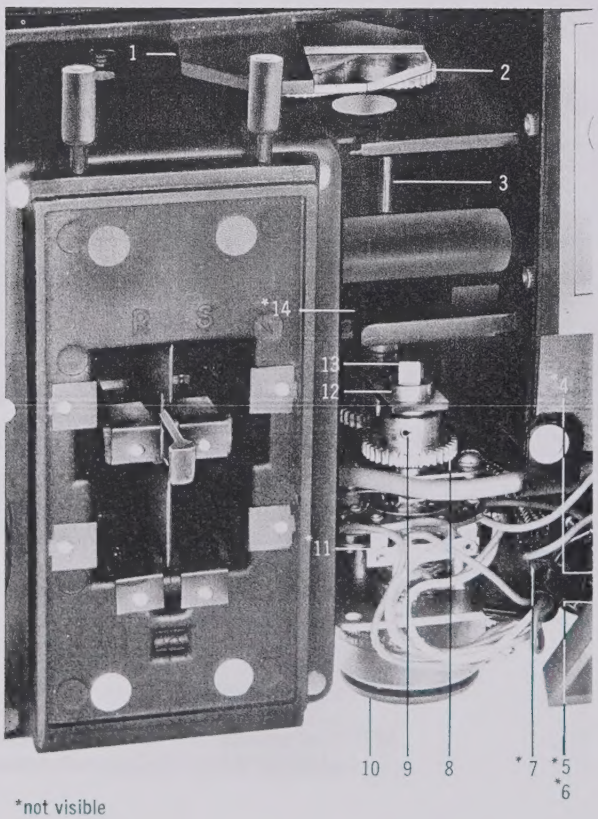


Figure 63. Internal View of Model DB-G Spectrophotometer

Reference Number	Beckman Part No.	Description	Circuit Reference
1	130857	Switch, Rotary, see Figure 64	S9
		Attaching Parts:	
	809901	Screw, Pan Head, 4-40 x ¼ (4)	
	808265	Washer, Split, No. 4 (4)	
2	105108	Filter Assembly, cemented in place	

NOTE: See Figures 40 and 57 for other components applicable to Model DB-G Spectrophotometer



*not visible

Figure 64. Grating Switch Assembly and Related Components

Reference Number	Beckman Part No.	Description	Circuit Reference
1	105108	Filter Assembly, cemented in Place	
		Includes:	
	41653	Gear, 36T	
2	41653	Gear, 36T	
3	130859	Shaft, Filter	
4	832244	Rectifier, Silicon Bridge	CR7
		Attaching Part:	
	808267	Washer, Split, No. 6 (2)	
5	817927	Diode	CR10
6	804719	Capacitor, 0.01 μf, 1000 volts	C29
7	130856	Bracket, Solenoid	
		Attaching Parts:	
	824720	Screw, Pan Head, 6-32 x 5/8 (2)	
	809924	Screw, Pan Head, 6-32 x 3/8 (1 only)	
	809925	Screw, Pan Head, 6-32 x 1/2 (1 only)	
	808267	Washer, Split, No. 6 (2)	
	816616	Washer, Flat, No. 6 (2)	
8	÷131942	Gear, 36T	
9	÷15769	Pin, Roll, 3/32" x 1/2"	
10	÷838179	Switch, Rotary	S9
11	130858	Plate, Nut	
12	130854	Bearing Plate Assembly	
13	130860	Spacer, Bearing Plate	
14	105142	Shaft, Filter	
		Attaching Part:	
	23238	Ring, Retaining	

÷Components of 130857 Switch Assembly

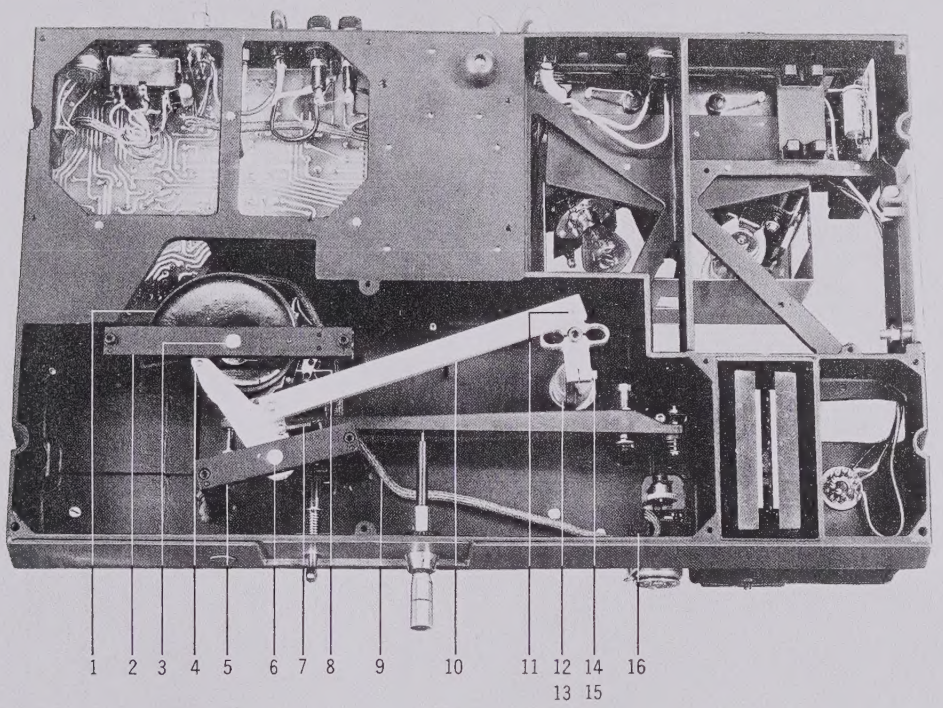


Figure 65. Internal Bottom View of Model DB-G Spectrophotometer

Reference Number	Beckman Part No.	Description	Circuit Reference
1	105140	Cam Assembly	
2	105107	Strap, Cam Assembly	
		Attaching Parts:	
	807803	Screw, Hex Socket Cap, 8-32 x ½ (2)	
	808269	Washer, Split, No. 8 (2)	
3	106785	Pivot, Bearing	
		Attaching Parts:	
	28764	Slug, Nylon	
	29834	Setscrew, Hex Socket Cap, 4-40 x ⅛	
4	105106	Follower Assembly	
5	105109	Strap, Follower Assembly	
		Attaching Parts:	
	807803	Screw, Hex Socket Cap, 8-32 x ½ (2)	
	808269	Washer, Split, No. 8 (2)	
6	106784	Pivot, Bearing	
		Attaching Parts:	
	40692	Ball, Stainless Steel, 3/16" dia	
	28764	Slug, Nylon	
	29834	Setscrew, Hex Socket Cap, 4-40 x ⅛ (2)	
7	28151	Spring, Extension	
8	29678	Switch, Sensitive, see Figure 66	S5,S6,S7,S8
9	105163	Harness	
10	131982	Arm, Follower	
11	106783	Pivot, Bearing	
		Attaching Part:	
	816616	Washer, Flat, No. 6	
12	105134	Grating Assembly, includes Items 13 and 14	
		Attaching Parts:	
	105772	Strap, Grating	
	106784	Pivot, Bearing	
	28764	Plug, Nylon	
	29834	Setscrew, Hex Socket Cap, 4-40 x ⅛	
13	132868	Shield, Grating	
		Attaching Parts:	
	816040	Screw, Pan Head, 4-40 x ⅜	
	828560	Washer, Flat, No. 4	
	828568	Washer, Split, No. 4	
14	807802	Screw, Hex Socket Cap, 6-32 x ¾	
15	816616	Washer, Flat, No. 6	
16	3343	Clamp, Cable, 3/16"	
		Attaching Parts:	
	816266	Washer, Split, No. 5	
	816616	Washer, Flat, No. 6	
	802229	Nut, Hex, 5-40	

Description	S5	S6	S7	S8
Switch, Sensitive	29678	29678	29678	29678
Actuator, Switch (includes attaching hardware)	99337	99337	99337	99337
Bracket, Switch	105153	105152	105151	—
Washer, Split, No. 4	808265	808265	808265	—
Screw, Pan Head, 4-40 x 5/16	824870	824870	824870	—
Plate, Nut	129952	129952	129952	—
Plate, Switch	—	—	—	132825
Washer, Flat, No. 2 (2)	—	—	—	809198
Screw, Pan Head, 2-56 x 3/8 (2)	—	—	—	809871

Figure 66. Filter Actuating Switches

Figure 67. Supplies for 1401, 1402, 1403 and 1404 Spectrophotometers

Beckman Part No.	Description	Quantity Furnished
148	Fuse, Electrical, 1.0 amp, 250 volts	5
801545	Fuse, Electrical, 0.2 amp, 250 volts	5
893	Resistor, 56 ohms ±5%, ½ watt	1
6543	Resistor, 510 ohms ±5%, ½ watt	1
49890	Recorder Cable Assembly	1
12576	Block, Opaque	1
75172	Cell, Silica Absorption, 10 mm pathlength	set of 2
16988	Plug, Adapter	1
817304	Wrench, Hex, 7/64"	1
817305	Wrench, Hex, 9/64"	1
1894	Wrench Set, Hex	1
134166	Cover, Dust	1
816104	Screw, Pan Head, ¼-20 x 3/8	2
79185	Washer, Flat, ¼	2

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